US Army Corps
of Engineers
St. Paul District

SUMMARY OF REVEGETATION WORK ON DREDGED MATERIAL SITES IN THE ST. PAUL DISTRICT, CORPS OF ENGINEERS

by

Robert Anfang, St. Paul District, Corps of Engineers

and

Gary Wege, St. Paul Field Office, U.S. Fish and Wildlife Service

May 1989

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704 0188
Exp Date Jun 30 1986

1a REPORT SECURITY CLASSIFICATION: Unclassified

1b RESTRICTIVE MARKINGS:

2a SECURITY CLASSIFICATION AUTHORITY:

2b DECLASSIFICATION / DOWNGRADING SCHEDULE:

3 DISTRIBUTION / AVAILABILITY OF REPORT: Approved for public release; distribution unlimited.

4 PERFORMING ORGANIZATION REPORT NUMBER(S):

5 MONITORING ORGANIZATION REPORT NUMBER(S):

6a NAME OF PERFORMING ORGANIZATION: U.S. Army Engineer Dist., St Paul

6b OFFICE SYMBOL (If applicable): CENCSPD-ER

7a NAME OF MONITORING ORGANIZATION:

6c ADDRESS (City, State, and ZIP Code): 1421 USPO & Custom House
St Paul, MN 55101-1479

7b ADDRESS (City, State, and ZIP Code):

8a NAME OF FUNDING / SPONSORING ORGANIZATION:

8b OFFICE SYMBOL (If applicable):

9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER:

8c ADDRESS (City, State, and ZIP Code):

10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO	WORK UNIT ACCESSION NO

11 TITLE (Include Security Classification)

SUMMARY OF REVEGETATION WORK ON DREDGED MATERIAL SITES IN THE ST. PAUL DISTRICT, CORPS OF ENGINEERS.

12 PERSONAL AUTHOR(S)

Roberg Anfang; Gary Wege

13a TYPE OF REPORT	13b TIME COVERED FROM ____ TO ____	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
		May 1989	

16 SUPPLEMENTARY NOTATION

17 COSATI CODES		
FIELD	GROUP	SUB-GROUP

18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)

Dredged Material
Mississippi River
Revegetation

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

This report summarizes the results of dredged material revegetation work that has been conducted in the St. Paul District. All of this work has taken place along the Mississippi River between Minneapolis, Minnesota and Prairie du Chien, Wisconsin, in Pools 1 through 9. Revegetation of dredged material disposal sites started in 1982 and is currently being conducted on projects suggested by the Great River Environmental Action Team (GREAT).

20 DISTRIBUTION / AVAILABILITY OF ABSTRACT
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS

21 ABSTRACT SECURITY CLASSIFICATION: Unclassified

22a NAME OF RESPONSIBLE INDIVIDUAL:

22b TELEPHONE (Include Area Code):

22c OFFICE SYMBOL:

DD FORM 1473, 84 MAR

83 APR edition may be used until exhausted
All other editions are obsolete

SUMMARY OF REVEGETATION WORK ON DREDGED MATERIAL SITES

IN THE ST. PAUL DISTRICT, CORPS OF ENGINEERS

BY

ROBERT ANFANG, ST. PAUL DISTRICT, CORPS OF ENGINEERS

AND

GARY WEGE, ST. PAUL FIELD OFFICE, U.S. FISH AND WILDLIFE SERVICE

This report summarizes the results of dredged material revegetation work that has been conducted in the St. Paul District. All of this work has taken place along the Mississippi River between Minneapolis, Minnesota and Prairie du Chien, Wisconsin, in Pools 1 through 9. Revegetation of dredged material disposal sites started in 1982 and is currently being conducted on projects suggested by the Great River Environmental Action Team (GREAT).

GENERAL

The 9-foot navigation channel within the St. Paul District is an existing operational project consisting of 13 locks and dams, supplemented by maintenance dredging, that facilitates navigation on the upper reaches of the Mississippi River system. The St. Paul District maintains a 9-foot navigation channel in the Upper Mississippi River from the head of navigation at Minneapolis, Minnesota (river mile 857.6) to just below lock and dam 10 at Guttenberg, Iowa (mile 614.0), for a total distance of 243.6 river miles (see Appendix 1).

The Mississippi River headwaters are in north-central Minnesota, a relatively flat area where streams meander through shallow valleys. This part of the Mississippi River is too shallow for commercial navigation. But where the Mississippi River reaches Minneapolis, in central Minnesota, it flows in a narrow valley with steep bluffs on either side.

The gradient of the riverbed where the Mississippi River flows into Minneapolis is the steepest of the entire river. Consequently, the locks in this area have the greatest lifts of all the locks in the Mississippi River navigation system. Sediment deposits in this area consist of medium to coarse sands. Beaches in this area receive heavy use from the metropolitan area.

Downstream of St. Paul, the Mississippi River spreads into a wide floodplain developing an extensive system of lakes and sloughs, the more prominent of which are Lake Pepin, Weaver Bottoms, Lake Onalaska, and Reno Bottoms. Sediment in these areas is primarily medium to fine

sands.

The dredged material generated by the maintenance activities consists mostly of medium sized sand, which is usually placed in confined disposal sites in the river valley. A concern at these sites is to minimize erosion, provide some wildlife habitat, and improve the aesthetic appearance. The primary method used to achieve these goals is revegetation with grasses.

The sand dredged material is very slow to revegetate naturally, and it is not uncommon to see bare sand with only scattered weed growth 20 or more years after disposal. These areas are very low in fertility but will support the growth of trees, primarily oak, shrubs and grasses.

In 1988, selected recommendations of GREAT were implemented, which consisted of creating islands in backwater areas and closing side channels for environmental benefits. These areas have also undergone various treatments, including revegetation, to reduce erosion and provide wildlife habitat.

Since the sites were established, most of them have been monitored on a yearly basis. The monitoring consists of randomly selected 4 square meter plots on which percent cover and species composition are recorded. In addition, random releve' plots are taken recording species composition. The results of these experiments are summarized in this report.

REVEGETATION SITES IN THE ST. PAUL DISTRICT

Appendix 2 includes a list of all dredged material revegetation sites in the St. Paul District and gives a summary of the revegetation practices employed on them. Maps showing the location of the sites are also included. Photographs of the revegetation sites are shown in Appendix 5. Common and scientific names of plant species used in this report are included in Appendix 6.

Lost Island

The first experience with revegetation of dredged material took place on the side slopes of a confined disposal site on Lost Island in Pool 5 at river mile 745.0. On 14 May 1982, an area of about 3 acres was broadcast seeded and hydromulched. The total cost of the operation, not including the use of Corps equipment to barge the contractor's seeding and mulching equipment to the site, was about $7,000. The seeded species included:

Red clover (*Trifolium pratense*)	8 lbs./acre
Yellow sweet clover (*Melilotus officinalis*)	13 lbs./acre
Switchgrass, Blackwell (*Panicum virgatum*)	8 lbs.PLS/acre[1]
Sand dropseed (*Sporobolus cryptandrus*)	8 lbs.PLS/acre
Annual rye (*Lolium sp.*)	13 lbs./acre

[1] PLS is defined as Pure Live Seed

In addition, 50 lbs. of the following seed mixture was applied:

Brome grass
Perennial ryegrass
Timothy
Birdsfoot trefoil

The seeded area was fertilized at a rate of 600 lbs./acre of 19-19-19 (N-P-K). The fertilizer was applied with the hydromulch after the area was broadcast seeded.

At the southern end of the island a small test plot was established by seeding 50 lbs./acre of rye (*Secale cereale*). No fertilizer or mulch was applied to this area.

On 16 May 1983 the downstream half of the hydromulched area was fertilized again using a hand spreader at a rate of about 400 lbs./acre of 19-19-19 (N-P-K).

On 22 May 1985 about 1/2 acre of the hydromulched area on the downstream portion of the site was second seeded with the following seed mixture. The seed was broadcast using a Cyclone seeder. Total cost was about $150 for the seed.

Blazer perennial ryegrass	10 lbs.
Switchgrass (*Panicum virgatum*)	1 lb. PLS
Side oats grama (*Bouteloua curtipendula*)	1 lb. PLS
Little bluestem (*Andropogon scoparius*)	2 lbs. PLS
Big bluestem (*Andropogon gerardi*)	1 lb. PLS
Canada wild rye (*Elymus canadensis*)	0.5 lb. PLS
Crown vetch (*Coronilla varia*)	2 lbs. PLS

Lost Island has been monitored yearly since the original seeding in 1982. The following table shows the results of the monitoring activities.

	PERCENT COVER	
Date	Seeded Area	Control Area
June 1982	5.5	1.2
August 1982	33.2	8.3
July 1983	11.5	15.5
August 1984	15.6	8.3
August 1985	20.4	4.1
August 1986	38.1	9.1
August 1987	45.0	19.5
August 1988	41.5	16.6

The site was visited about 1 month after seeding in June 1982. It was difficult to distinguish any difference between the seeded and control areas. Species found on the sites included: clammyweed (*Polanisia graveolens*), white sweet clover (*Melilotus alba*), red clover (*Trifolium pratense*), winged pigweed (*Cycloloma atriplicifolium*), pennycress (*Thlaspi arvense*), hoary alyssum (*Berteroa incana*), and unidentified grasses. The red clover and some of the grasses are species that were

included in the seed mixture.

The site was visited again in August of the same year with vastly different results, as can be seen in the percent cover table. Winged pigweed, an annual that readily invades sandy areas, represented most of the percent cover on the study plots, while it appeared that grasses had the most stem density. The fertilizer had a tremendous effect, although it turned out to be only short term. The winged pigweed was about 20 inches tall and 2 feet in diameter on the fertilized area but only about 3 inches tall on the unfertilized control site.

Other species found included sand dropseed (*Sporobolus cryptandrus*), red clover, rye (*Lolium sp.*), willow (*Salix sp.*), lambsquarters (*Chenopodium album*), umbrella sedge (*Cyperus schweinitzii*), bindweed (*Convolulus sp.*), spiderwort (*Tradescantia sp.*), quackgrass (*Agropyron repens*), and thistle (*Cirsium sp.*).

Although the winged pigweed is an annual, successional studies have shown that it persists for a number of years after it is established. The sand dropseed is a perennial and should maintain itself.

The test plot at the south end of the island that was seeded with annual rye had germinated but not set seed in August 1982.

On 16 May 1983 the downstream half of the seeded area was fertilized. The results of the August 1983 monitoring studies are presented below.

SITE	PERCENT COVER	STEM DENSITY
Hydromulched area		
Fertilized	6.6	4.4
Unfertilized	16.5	11.7
Control area	15.5	3.9

The species composition between the seeded and control plots was essentially the same. The height and abundance of the vegetation were greater in the seeded area.

The area fertilized in May had less percent cover and fewer stems per quarter-square meter than the unfertilized area. The vegetation in the fertilized area appeared less vigorous and more brown in color. Hollis Allen of the Waterways Experiment Station believed that the fertilizer was applied too early and it burned the vegetation. They have had similar experiences on their test plots. (Personal communication)

Winged pigweed was much less dominant in the area in 1983, as opposed to 1982. This is not unexpected because other studies have also shown that winged pigweed becomes less dominant over time (Waterways Experiment Station Technical Report D-77-31, "The Flora of Dredged Material Sites in Navigation Pool 8 of the Upper Mississippi River"). Other species found in the seeded area included willow, sand dropseed, clammyweed, sedge, and yellow sweet clover (*Melilotus officinalis*). The sand dropseed and clover were among the species originally seeded. The sand dropseed is beginning to form clumps and is fairly well

distributed. Looking back, there was probably some switchgrass present at this time also but it was not identified.

The rye plot on the south side of the island was about 2 feet tall and had set seed. Subsequent monitoring of this plot revealed that the rye became less dense over the years and had essentially disappeared by 1985. This site was abandoned.

In August 1984, the effects of the previous year's fertilization could not be detected so the fertilized area was not sampled separately.

The seeded area looked much more impressive this year. The area had very few weedy species as compared to the control area and had developed a good stand of grasses. Much of the area was still open (15% ground cover) but this is the nature of the grass species (not sod-forming) and a complete ground cover cannot be expected to occur on these disposal sites.

Two years after seeding, the area exhibited about twice the percent cover as the control area. Winged pigweed was absent in the seeded area except on recently disturbed locations. Species composition on seeded study plots included sand dropseed, brome (*Bromus sp.*), panicum, and purple sandgrass (*Thalapsis purpura*). The grasses were about 24 inches in height. Other species observed included timothy (*Muhlenbergia racemosa*), clammyweed, rye, and bindweed (*Convolulus sepium*). No clover species were found in the seeded area. The control area contained many similar species plus the winged pigweed and clammyweed. Although the control area had a higher stem density, fewer grass species were present, the vegetation was shorter (about 6 inches with the exception of the sand dropseed), there was a higher proportion of weedy species, and the percent cover was lower. Seeding appears to have accelerated the successional process by about 5 to 7 years.

Litter cover began to accumulate during 1985. Monitoring that year estimated litter cover at about 8 percent. No litter has been observed on the control area. As stated earlier, a portion of Lost Island was second seeded using a Cyclone seeder. No difference was observed as a result of the second seeding this year or in subsequent years.

The species found in the seeded area were by far predominantly grasses while the control area was dominated by weed species. The following table shows the dominant species composition in 1985.

Seeded Area	Control Area
brome	winged pigweed
switchgrass	clammyweed
sand dropseed	switchgrass
willow	sand dropseed
purple sandgrass	willow
winged pigweed	
grape	
clammyweed	

During 1986, dredged material was placed in the confined disposal area

at Lost Island, and some of the seeded area was affected by construction equipment. In these areas, the seeded species were destroyed and the successional process was set back to year 1. Winged pigweed and clammyweed were the only species found on these disturbed sites.

On the undisturbed seeded areas, the grass species, primarily switchgrass and sand dropseed, were robust and vigorous, while the control area was dominated by weedy species. Cover on the seeded area was about 45 percent while the control area was only 19 percent. The grass vegetation on the seeded area was about 5 to 6 feet tall whereas the control area was typically short weed species. Species identified included:

Seeded Area	Control Area
switchgrass	winged pigweed
purple sandgrass	clammyweed
sand dropseed	sand dropseed
brome	purple sandgrass
quackgrass	willow
sedge	sandbur
winged pigweed	brome
clover	milkweed
goosefoot	

Much of the country was experiencing a drought during 1987 and 1988. It was uncertain what to expect of the revegetation in this area. Monitoring in 1988 revealed that the drought had little effect on the vegetation. The area had a very good growth of switchgrass and sand dropseed. Canada wild rye was also seen in the second seeded area for the first time. This species was seeded in 1985. One reason that the drought seems to have had little effect is that the roots of these species penetrate about 2 to 3 feet into the sand.

The seeded area had a very good growth of grasses whereas the control area was still dominated by weedy species. Species identified on the sample plots included the following:

Seeded Area	Control Area
sand dropseed	purple sandgrass
brome	carpetweed
switchgrass	winged pigweed
willow	clammyweed
bindweed	willow
Virginia creeper	sand dropseed
milkweed	Virginia creeper
purple sandgrass	
winged pigweed	
sedge	

In summary, it appears that the seeding of Lost Island was successful, although it took about 3 years before the seeded species started to

appear and about 5 years before a good grass cover of about 40 percent was apparent. The dominant grass species are switchgrass and sand dropseed, both of which are natural invaders of sandy areas but usually take many decades before they reach the density and cover found on Lost Island. The control area after 7 years, is still dominated by weeds such as winged pigweed and clammyweed. Sand dropseed is found on the control plots but not to the extent of that on the seeded area.

Teepeeota Point

Teepeeota Point is a confined disposal area at river mile 757.3. It is used periodically for the disposal of dredged material and receives fairly heavy human use.

Teepeeota Point was the St. Paul District's first large scale attempt to place fine material on top of the sand to try to create a more suitable substrate for the growth of vegetation. (See Appendix 3, prepared by Marc Krumholz of the St. Paul District, for a detailed description of the dredging activities).

From 8 August to 13 September 1984, fine material was dredged from a backwater area near the island using a Mud Cat and pumped onto the site through an 8-inch pipe. The first method of placement involved cutting holes in the pipe to allow the fine material to escape, but this caused erosion of the side slopes of the disposal site. The next method involved excavating pits and pumping the fine material into them but they soon overflowed and also eroded. The final method used an irrigation sprayer which was dead-headed to a bulldozer and automatically retrieved from up to 600 feet away using a winch. This procedure allowed the fine material to dry slightly and the water to soak away or run off between applications of the fine material. This method appeared to be working and capable of applying an adequate amount of fine material. However, the contract was beginning to expire and it was not possible to apply more than about 1/4 inch of fine material over the area. Overflow from the dredge was pumped into the bottom of the disposal site where it accumulated to a thickness of at least 6 inches. No vegetation seeding was conducted at Teepeeota Point.

The placement of fine material on Teepeeota Point cost about $42,000, including equipment rental and Corps-provided labor. It was estimated that this cost could be reduced by almost 60 percent, bringing the cost down to about $1,500 per acre. See Appendix 3 for additional information.

Even though only about 1/4 inch of fine material was placed on the side slopes of the disposal site, it appears that this was enough to produce some benefits for enhancing the growth of vegetation. The main advantage that the fine material adds over the pure sand is that it retains moisture better which contributes to the growth of the vegetation. The treated area and a control site at Teepeeota Point have been monitored yearly since 1985. The percent cover estimates from the monitoring activities are shown in the following table.

	PERCENT COVER			
Area	Aug.1985	Aug.1986	Aug.1987	Aug.1988
Fine Sediment	20.5	19.6	16.5	13.6
Control	3.5	7.5	9.6	0.4

In 1985, the only species growing on the control site were sedge and switchgrass. Species found on the treated area were winged pigweed, sedge, switchgrass, aster, mustard, and clammyweed. In the bottom of the bathtub where the sediment had accumulated to a thickness greater than 10 inches, the percent cover for vegetation was over 80 percent and the following species were observed:

Russian thistle
lambsquarters
milk purslane
carpetweed
cinquefoil
wild rye
winged pigweed
smartweed
sweet clover
curly dock
primrose
barnyard grass
bindweed
rye
foxtail
box elder
sand dropseed
switchgrass
sedge
clammyweed
silver maple
elm
thistle
milkweed
bouncing bet

When the site was revisited in 1986, it had been used for disposal activities and the bottom of the bathtub was covered by sand, which eliminated the species growing on the fine material.

The percent cover on the treated side slope had not changed substantially from the preceding year, as can be seen in the summary table above, but the species composition now included the following:

Fine Sediment Area	Control Area
switchgrass	switchgrass
Canada wild rye	mustard
horseweed	sedge
tumbling mustard	oak
sedge	tumbling mustard
mustard	

The percent cover decreased in 1987 and 1988, possibly for two reasons: 1) the fine material seems to be getting more incorporated with the sand every year and is losing its effectiveness, and 2) the area was experiencing a drought during 1987 and 1988.

Species composition did not vary substantially between the two years and included the following species:

Fine Sediment Area	Control Area
sand dropseed	sand dropseed
sedge	sedge
purple sandgrass	purple sandgrass
marestail	mustard
Russian thistle	grape
Canada wild rye	
daisy fleabane	

In summary, placing fine sediment on top of the sand does seem to encourage the growth of vegetation. Even small amounts of sediment will help. The irrigation sprayer appears to be an effective method of placing the fine material, although it may be more time consuming than traditional methods such as tractors and off-loading from barges, and does require some special equipment.

Weaver Bottoms-Islands and Closures

Weaver Bottoms, a backwater of the Mississippi River, is located at river mile 745.0, near Lost Island. In order to improve the quality of the backwater area, two islands and a number of side channel closures were constructed to influence flows and sedimentation (see Appendix A for a plate showing the locations of the islands and closure structures). The sand used to construct the islands and closures came from confined disposal sites at Lost and Fisher Islands. After meetings with State and Federal natural resource agencies, it was decided that it would be desirable to provide a cover of vegetation on the islands and closures to enhance waterfowl nesting, and a number of techniques were identified to use on the islands and closures. Both islands were covered with about 6 inches of fine material that was dredged from the area between the two islands. After the material had dried, some of it was barged to four of the closures and incorporated into the sand.

Both Swan and Mallard Islands had about 6 inches of fine material placed on top of the sand. The fine sediment was incorporated with the sand using a disk or bulldozer. Due to the thickness of the fine material the disk did not mix the fine material with the sand to a great degree and resulted in a silt/clay surface soil (Swan Island). Using a bulldozer with the blade slightly tilted and making several passes over the surface resulted in better incorporation and a coarser soil texture, which may result in better soil aeration and growing conditions (Mallard Island and the side channel closures). Mallard Island was used as a control and did not receive any further treatment. The incorporation of fine material on Mallard Island was completed in July 1988. Swan Island was drill seeded with the following species, and the side slopes were mulched with 1 ton/acre of hay and anchored using a disk.

The following seed mixture was applied to the dry zone above elevation 663.

Species	Variety	Seeding Rate
Indiangrass	Nebraska 54	4 lbs.PLS/acre
switchgrass	Nebraska 28	2 lbs.PLS/acre
little bluestem	Camper	3 lbs.PLS/acre
sand reedgrass	Goshen	1 lb.PLS/acre
sand dropseed	South Dakota	1 lb.PLS/acre
side oats grama	Butte	1 lb.PLS/acre
Canada wild rye		1 lb.PLS/acre

The following seed mixture was applied to the wet zone below elevation 663.

Species	Variety	Seeding Rate
prairie cordgrass	Minnesota	5 lbs.PLS/acre
Canada wild rye		4 lbs.PLS/acre
big bluestem		2 lbs.PLS/acre
switchgrass	Nebraska 28	2 lbs.PLS/acre
Indiangrass	Nebraska 54	2 lbs.PLS/acre

Drill seeding of Swan Island was completed by 15 June 1988.

Six side channel closures were involved in this revegetation study: 4 in Minnesota and 2 in Wisconsin. The treatment given to each of these areas will be discussed separately. Each closure is numbered and listed by the State in which it is located.

MN 10 - Control site. No fine material was placed or seeding conducted.

MN 11 - Fine material was placed on the side slope and top of the closure and incorporated with the sand. Prairie cordgrass was drill seeded in the wet zone below elevation 663 at the rate of 10 lbs.PLS/acre. In the area above elevation 663 and on the flat top of the closure the following seed mixture was drill seeded. Mulch was applied to the side slope of the closure at the rate of 1 ton per acre and anchored.

Species	Seeding Rate
little bluestem	4 lbs.PLS/acre
side oats grama	4 lbs.PLS/acre
switchgrass	4 lbs.PLS/acre

MN 12 - No fine material was placed on this closure. Three rows of American beachgrass sprigs were planted 1 foot apart in the wet zone below elevation 663. Sand dropseed was drill seeded on the rest of the side slope and flat top of the closure at the rate of 18 lbs.PLS/acre. Mulch was applied to the seeded side slope at the rate of 1 ton per acre and anchored.

MN 13 - Fine material was placed on this closure and incorporated with the sand. Three rows of rice cutgrass sprigs were planted 1 foot apart in the wet zone below elevation 663. The following seed mixture was drill seeded on the side slope above elevation 663 and on the flat top of the closure. Mulch was applied to the seeded side slope at the rate of 1 ton per acre and anchored.

Species	Seeding Rate
thickspike wheatgrass	6 lbs.PLS/acre
green needlegrass	5 lbs.PLS/acre
Canada wild rye	5 lbs.PLS/acre

WI 10 B and C - Fine material was placed on each of these 1/2 acre closures and incorporated with the sand. The following seed mixture was divided equally and drill seeded on each of the two closures. No mulch was applied.

Species	Amount of Seed
prairie dropseed	13 lbs.
big bluestem	10 lbs.
side oats grama	5 lbs.
Indiangrass	10 lbs.
showy sunflower	10 oz.
rough blazing star	20 oz.
black-eyed Susan	10 oz.

All of the work on the side channel closures was completed in July 1988.

The total cost of the seeding operations on Swan Island and the side channel closures was about $60,000. This does not include costs associated with dredging or placing fine material on the sites.

The revegetation sites were first monitored in August 1988. The central portions of the islands were used as the sample locations because the fine material appeared to be rather thin on the ends of the islands and we wanted to determine the effectiveness of fine material on the growth of vegetation. The top and the side slope of the islands were sampled separately because of the noticeable difference in growth and different mulch treatment. Wild oats was present in the mulch and is growing very well on the side slope of Swan Island. This should provide a good mulch for next year. Some shoreline plantings were conducted by the Winona Office of the U.S. Fish and Wildlife Service. We are not monitoring these plantings but some of them appear to be doing very well, especially the bulrush and willow.

Percent cover estimates for Swan and Mallard Islands are presented below. Fine material was final graded on Mallard Island about 2 weeks prior to monitoring so there was no growth at the time of monitoring.

LOCATION	PERCENT COVER Aug.1988
Swan Island	
Top	4.0
Side Slope	14.3
Mallard Island	
Top	0.0
Side Slope	0.0

Species found on the sample plots on Swan Island included the following:

Top	Side Slope
winged pigweed	wild oats
switchgrass	switchgrass
side oats grama	side oats grama
wild oats	rough pigweed
sand dropseed	unidentified grass
unidentified grass	

All of the seeded side channel closures were monitored for percent cover and species composition. The Minnesota closures were sampled on both the top and side slope because of the different treatments. The Wisconsin closures are of a different shape and received only one seeding treatment. The results of the monitoring are presented below.

LOCATION	PERCENT COVER Aug. 1988
MN 10	
Top	13.3
Side Slope	7.0
MN 11	
Top	1.4
Side Slope	7.6
MN 12	
Top	1.7
Side Slope	1.1
MN 13	
Top	0.9
Side Slope	1.1
WI 10B	0.6
WI 10C	1.3

Closure MN 10 is the control treatment. From the above table, MN 10 has a higher percent cover than the other areas. This is misleading because the control area was not disturbed this year and has had 2 years to revegetate while the other closures were seeded only a month earlier.

Species found on MN 10 are shown below.

Species - Top	Species - Side Slope
winged pigweed	winged pigweed
purple sandgrass	purple sandgrass
sand dropseed	sand dropseed
sedge	Russian thistle
clammyweed	clammyweed

On closure MN 11, the side oats grama and switchgrass were growing very well. Sand dropseed was also coming in naturally. The species composition is shown below.

Species - Top	Species - Side Slope
side oats grama	side oats grama
crabgrass	crabgrass
	purslane
	rough pigweed
	wild oats

Closure MN 12 was seeded with sand dropseed. Sand dropseed was growing on the site but this could also be natural regrowth. Some winged pigweed was also present. Most of the beachgrass sprigs were brown and do not appear to be very vigorous, but they could come back next year from the roots as was the case at Crosby Island. The beachgrass should have been planted in middle to late May, but this was not possible due to contracting problems. The drought of 1988 could also be the cause of some of the poor condition.

The wet zone of closure MN 13 was planted with rice cutgrass sprigs. The sprigs are only about 3 inches tall when planted and could not be found during the 1988 sampling. There is some naturally occurring rice cutgrass in the area. Many of the grasses were too immature to identify. Some of the species present in 1988 included:

Species - Top	Species - Side Slope
winged pigweed	wild oats
foxtail	switchgrass
switchgrass	
clammyweed	

The Wisconsin closures were seeded just two weeks prior to the monitoring in 1988. There were some grasses germinating but they were too immature to identify.

The drought of 1987 and 1988 was not as severe in this area as in other areas. The area received about 1 to 2 inches of precipitation about every month, which is usually sufficient for the species seeded on the islands and closures. However, the effects of the drought could still be seen through less dense and less vigorous vegetation.

Crosby Island

Crosby Island is a confined disposal site located at river mile 690.5. Three different experiments have been conducted at this site, two by the Corps and U.S. Fish and Wildlife Service and one by the University of Wisconsin at La Crosse.

On 21 May 1985, approximately 3/4 acre of the sand side slope of the disposal site was broadcast seeded with the following seed mixture:

SPECIES	SEEDING RATE
blazer perennial ryegrass	15 lbs./acre
switchgrass	2 lbs./acre
side oats grama (*Bouteloua curtipendula*)	3 lbs./acre
little bluestem (*Andropogon scoparius*)	4 lbs./acre
big bluestem (*Andropogon gerardi*)	3 lbs./acre
Canada wild rye (*Elymus canadensis*)	1.5 lbs./acre
crown vetch (*Coronilla varia*)	3 lbs./acre

After the seed was broadcast, a fence was pulled over the area to incorporate the seed. Corps and Service labor was used for the seeding operation, which cost about $250 for the seed and fence.

Since the initial seeding the only species that seems to have germinated is the Canada wild rye. The percent cover is not very high, as can be seen from the following table, but it is vigorous and appears to be expanding.

	PERCENT COVER			
Area	Aug.1985	Aug.1986	Aug.1987	Aug.1988
Seeded	0.6	3.8	6.4	9.2
Control	3.6[1]	1.2	0.4	1.2

[1]In 1986, a more representative control area was selected which reflects the change in percent cover over 1985.

The species composition of the seeded and control areas is presented below.

Seeded Area	Control Area
Canada wild rye	sand dropseed
sand dropseed	purple sandgrass
Russian thistle	sedge
winged pigweed	mustard
clammyweed	grape
sedge	
purple sandgrass	
marestail	
evening primrose	

On 28 May 1974, Dr. Thomas Claflin of the University of Wisconsin at La Crosse planted American beachgrass (*Amophila brevilegulata*) sprigs on a low flat area near the present confined disposal site. In the 15 years since planting, these plants have expanded vegetatively about 200 feet from the original plantings. The beachgrass has formed a dense, almost monotypic mat. The expansion is entirely vegetative because this is a sterile strain of American beachgrass. In 1985, a small portion of the beachgrass plantings were burned by what appeared to be fireworks. By 1986, the effects of the fire had disappeared. Other species planted by the University included alder and white cedar, both of which are growing well near the water.

Beachgrass plantings have flourished in the low flat area but have not similarly revegetated the side slopes. On 30 April 1986, about 120 American beachgrass sprigs were transplanted to the side slope of the disposal site to see if the species can survive higher, drier sites.

In the fall of 1986, it appeared that recreationists had destroyed the transplanted beachgrass sprigs. However, in 1987, two plants were growing at the site. These plants were vigorous and healthy and should expand vegetatively. Although growth is much slower on the slopes, the plants do survive.

Jackson Island

In late May 1984, fine sediment from the auxiliary lock at Lock and Dam No. 9 was placed on a 1-acre site on Jackson Island at river mile 644.5. The sediment contained a high amount of clay and dried to produce a very hard and cracked surface. The area was seeded with the following mixture, but it could not be incorporated into the soil. A bulldozer ran over the area after seeding. Corps and Service employees were used to conduct the seeding operation, which cost approximately $200 for the seed.

Species	Pounds of Seed Bulk	PLS
switchgrass, ND 29	7	5
big bluestem, Sherburne Co. 1983	10.5	7.5
side oats grama, Killdeer variety	10.5	7
Indiangrass, Anoka Co. 1983	10	7.5

The post-seeding environment was not ideal for germination either. About two weeks after seeding, high water flooded the area.

The site has been monitored since 1986. Percent cover and percent presence (percent of plots on which species were present) of the seeded species are presented in the following tables.

Area	PERCENT COVER Aug.1986	Aug.1987	Aug.1988
Seeded Area			
Sand Sediment	38	48	23
Fine Sediment	92	77	38

Area and Species	PERCENT PRESENCE Aug.1986	Aug.1987	Aug.1988
Sand Sediment			
side oats grama	100	100	40
big bluestem	0	10	20
Fine Sediment			
side oats grama	30	20	10
big bluestem	20	70	0
Indiangrass	10	10	0

During the first two years after seeding, cottonwood and weedy grass species dominated the site. In 1987, Indiangrass, side oats grama, and the bluestems started to predominate but in 1988 they declined, possibly as a result of the drought conditions in 1988 and the preceding year.

In 1985 and 1986, a number of weedy species were present in the seeded area. The following is a partial list of species identified on releve' plots.

smartweed	brome	bluestem
switchgrass	cottonwood	thistle
Indiangrass	grape	evening primrose
sand dropseed	barley	ragweed
carpetweed	nightshade	little barley
spurge	side oats grama	quackgrass
foxtail	elm	red maple
lambsquarters	sedge	winged pigweed
sandbur	poison ivy	daisy fleabane
bindweed	horseweed	reed canary grass

After 1986, the weedy species seemed to be decreasing and the grass species increasing. In later years, the dominant species were:

elm	brome
sedge	side oats grama
big bluestem	sand dropseed
grape	

Island 58

In June 1985, fine sediment was removed from a nearby lock and placed on Island 58 at river mile 735.0. The fine material was spread over the sand on about 1/4 acre about 1 foot thick. No seed was applied.

The area has always had about 100 percent cover. The dominant vegetation is cottonwood, as opposed to other areas, which are usually

dominated by weeds and grasses. Species observed on the site in 1985 included:

cottonwood	sand dropseed
smartweed	velvet leaf
sedge	winged pigweed
clammyweed	milkweed
carpetweed	willow
rice cutgrass	yellow cress
Virginia creeper	rough pigweed
barnyard grass	bouncing bet
poison ivy	redroot pigweed

In 1986, the vegetation was about 6 to 7 feet tall and consisted of species similar to that of 1985 with the following additions:

reed canary grass
horseweed
clearweed
silver maple
sumac

The area was still densely vegetated in 1988, dominated by cottonwood, willow, and reed canary grass. The drought of 1987 and 1988 is also affecting this area as reflected by the thinner vegetation. As stated above, Island 58 is dominated by cottonwood whereas Jackson Island is mostly grass species with only a few scattered tree species. Cottonwood seemed to be more common on Jackson Island a few years back but has mostly disappeared. The reason for the difference between the two sites is not known -- possibly the closer proximity to forest vegetation at Island 58 and the grass seeding at Jackson Island have had an effect.

In summary, it appears that a sure way of getting vegetation to grow on a site is to place fine material over the sand, possibly with some incorporation. Seeding is not necessary. The first few years the site will be dominated by weedy species, but after about the fourth year, the diversity decreases and grass species emerge.

Island 42 - EMP Project

Island 42 is an Environmental Management Program (EMP) project with revegetation work conducted by the Minnesota Department of Natural Resources. Because of the Corps' and Service's interest in revegetation we have been monitoring this site to determine the results of the revegetation work.

Island 42 is located at river mile 749.0 and was seeded 12 June 1987. The seeded area consists of fine silt and clay that was sidecast from channel excavation. The area was broadcast seeded at the rate of about 100 lbs./acre with rye, bluegrass, brome, timothy, sand dropseed, and birdsfoot trefoil, and the seed was raked in. This seeding was

conducted at a much higher rate so it should prove to be a very good experiment.

In August 1987, the primary species observed was sand dropseed. Some birdsfoot trefoil was also seen.

Cover estimates were not taken until August 1988. At that time, the cover was estimated at 68 percent on quarter square meter plots. The dominant species present were sand dropseed and birdsfoot trefoil. Other species observed were brome, switchgrass, cottonwood, and quackgrass.

Wabasha Gravel Pit

The Wabasha Gravel Pit is located in the town of Wabasha, Minnesota, at approximately river mile 760.0. It is an abandoned gravel pit that was filled with dredged material when the historic disposal site at Reads Landing was removed. The area consists of about 30 acres of sand 30 to 40 feet deep. The area was seeded in 1985 in an effort to reduce wind erosion. Total cost of the seeding operation was about $40,000.

The area was broadcast seeded in September 1985, and the seed was incorporated with a spring-tooth harrow. The following seed mixture and rate were used.

Species	Seeding Rate
switchgrass	3 lbs.PLS/acre
yellow sweet clover	12 lbs./acre
alsike clover	6 lbs./acre
annual rye	10 lbs./acre

Percent cover estimates for the area are shown in the following table.

PERCENT COVER		
Aug.1986	Aug.1987	Aug.1988
14.6	11.4	15.6

Species observed at the gravel pit during monitoring activities included:

purple sandgrass	clammyweed
sand dropseed	foxtail
sedge	winged pigweed
switchgrass	crabgrass
carpetweed	alsike clover
brome	pineapple weed

The percent cover appears to be rather stable and not increasing. The lack of mulch or fine material was probably a factor. It could be concluded that more surface treatment is needed to achieve good growth.

Alma Marina

As a beneficial use of dredged material the Corps placed sand at the Alma Marina to create a recreation area for softball, volleyball, and similar activities. The city of Alma, Wisconsin placed 8 inches of clay on top of the sand disposal and drill seeded rye, fescue, and bluegrass in the fall of 1985 at the rate of 80 lbs./acre.

Visual monitoring shows that the area has a fairly heavy growth, over 70 percent cover, of alfalfa and bluegrass.

Minneapolis Park Beaches 1 and 2

Two temporary disposal sites are located at river miles 851.5 and 849.5 in the city of Minneapolis, Minnesota. They receive heavy beach use during the summer.

Site 1.03 at river mile 849.5 was drill seeded with the following species:

SPECIES	SEEDING RATE
sand dropseed	6 lbs.PLS/acre
switchgrass	6 lbs.PLS/acre
blue grama	17 lbs.PLS/acre
side oats grama	12 lbs.PLS/acre
little bluestem	4 lbs.PLS/acre
crown vetch	15 lbs./acre
Pennfine perennial rye	15 lbs./acre
Park Kentucky bluegrass	15 lbs./acre

Site 1.07 at river mile 851.5 was drill seeded with the following species:

SPECIES	SEEDING RATE
sand dropseed	8 lbs.PLS/acre
switchgrass	8 lbs.PLS/acre
blue grama	22 lbs.PLS/acre
side oats grama	16 lbs.PLS/acre
little bluestem	6 lbs.PLS/acre
crown vetch	10 lbs./acre
Pennfine perennial rye	20 lbs./acre
Park Kentucky bluegrass	20 lbs./acre

Prior to seeding, fertilizer was applied at the rate of 7 pounds per 1,000 square feet and incorporated to a depth of at least 2 inches by disking. The fertilizer was 19-19-19 (N-P-K).

The areas were seeded in November 1986. After seeding, hay mulch was applied at the rate of 2,000 lbs./acre and anchored using a disk harrow or similar device. Total cost of the seeding operation was about $10,000, or $1,900 per acre.

These sites have been revisited, but a formal monitoring program has not been implemented. These sites receive heavy use in the summer and the grass species have never had the opportunity to establish. During the summer after seeding, much of the hay mulch was gathered together and used in beach fires. Tree plantings have received similar treatment. Some grasses are growing on the sites, but it is impossible to interpret any results from these areas.

SUMMARY

Since 1982, the St. Paul District has conducted a number of revegetation studies on dredged material. The revegetation of bare sand is a lengthy process which takes approximately 3 to 4 years before the seeded species reach a ground cover of about 40 percent. It appears that sand dropseed and switchgrass are the species best suited to these sandy environments. Both of these species are found naturally on dredged material disposal sites but not in the density produced when seeded. Another species that appears to be showing some promise is Canada wild rye. This species seems to like the sand environment and deserves more consideration. It appears that mulch is needed if the seeding is done on bare sand. American beachgrass expands rapidly on the sand sites but produces a rather monotypic stand structure of limited value to wildlife.

If the goal is to achieve any type of cover in the shortest possible time, fine material must be placed on top of the sand to a thickness of at least 4 to 6 inches. Seeding is not necessary. Weedy species rapidly invade these areas but are replaced by higher quality grasses and herbs within 2 to 3 years. None of the seeded sites in the St. Paul District have been observed long enough to determine which species are best suited to the silt and clay sediment, but side oats grama and Indiangrass appear to grow well. Mulch is not needed if fine material is incorporated with the sand.

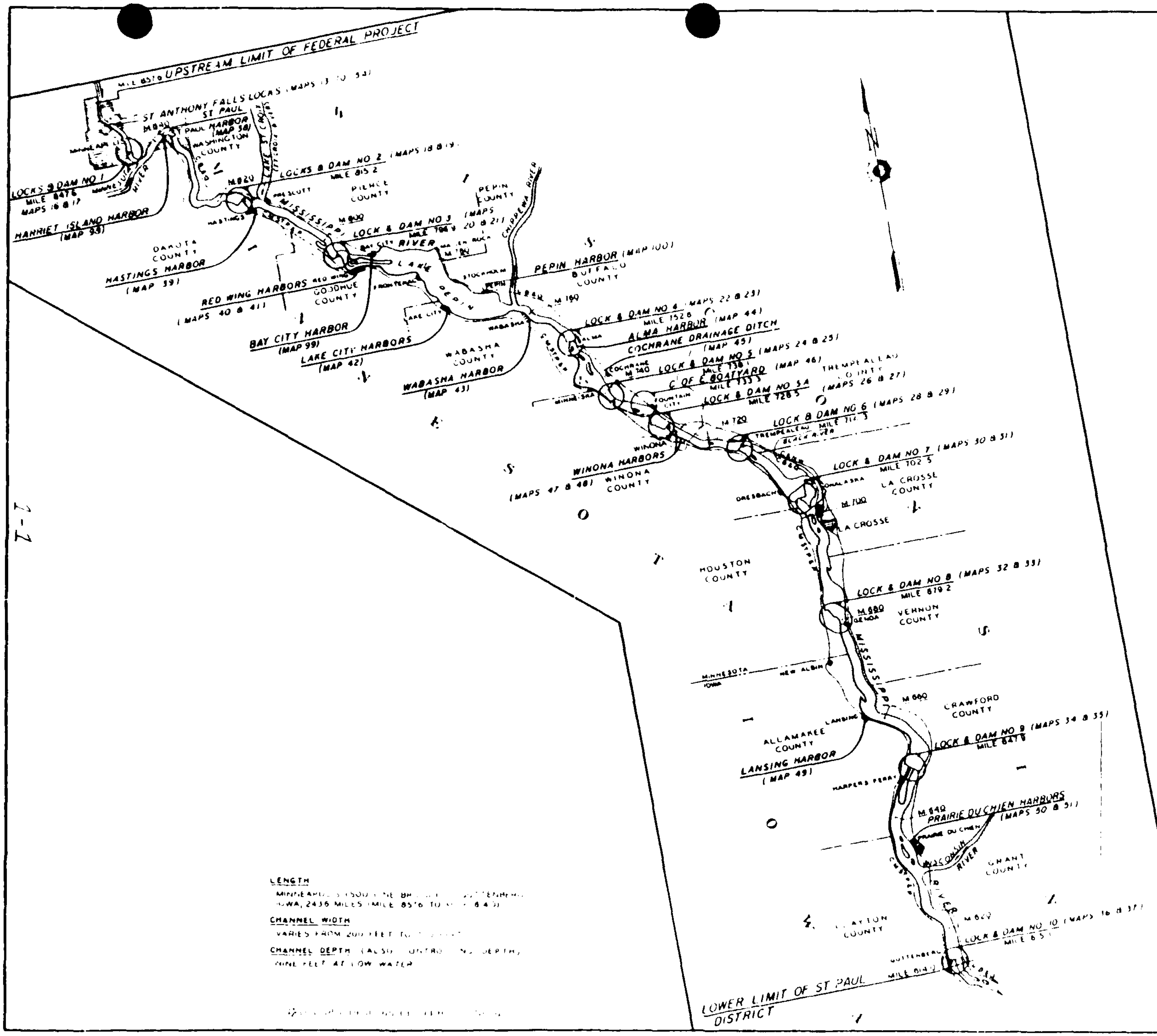
Photographs of the dredged material disposal sites, revegetated areas, and site treatments are presented in Appendix 5. A list of scientific and common names of species used in this report is provided in Appendix 6.

ACKNOWLEDGMENTS

None of this work could have been conducted without the support of the Construction-Operations Division of the St. Paul District. Dan Krumholz was especially instrumental by providing funds, administering contracts, providing mechanical equipment, suggesting sites, and supporting the entire program. Marc Krumholz, also of the Construction-Operations Division, administered contracts for the backwater dredging at Teepeeota Point and oversaw the entire operation. Dave Dralle and John Kittelson, both formerly of the Environmental Resources Branch, were involved in monitoring the early stages of the work. Marilyn Kruchten of the Planning Division, edited the report.

APPENDIX 1

MISSISSIPPI RIVER PROJECT AREA MAP



LENGTH
MINNEAPOLIS [illegible] GUTTENBERG IOWA, 243.6 MILES (MILE 857.6 TO [illegible] 614.0)

CHANNEL WIDTH
VARIES FROM 200 FEET TO [illegible]

CHANNEL DEPTH (ALSO [illegible] DEPTH) NINE FEET AT LOW WATER

NOTE
RIVER WIDTH IS NOT TO SCALE

M.610 [illegible] MILES ABOVE OHIO RIVER AT CAIRO, ILL

ELEVATIONS ARE REFERRED TO [illegible]

RIVER & HARBOR PROJECT
MISSISSIPPI RIVER
MISSOURI RIVER TO MINNEAPOLIS MINN
PROJECT MAP

SCALE IN MILES

CORPS OF ENGINEERS [illegible]
OFFICE OF THE DISTRICT ENGINEER
ST PAUL DISTRICT [illegible]
30 SEPTEMBER [illegible]

APPENDIX 2

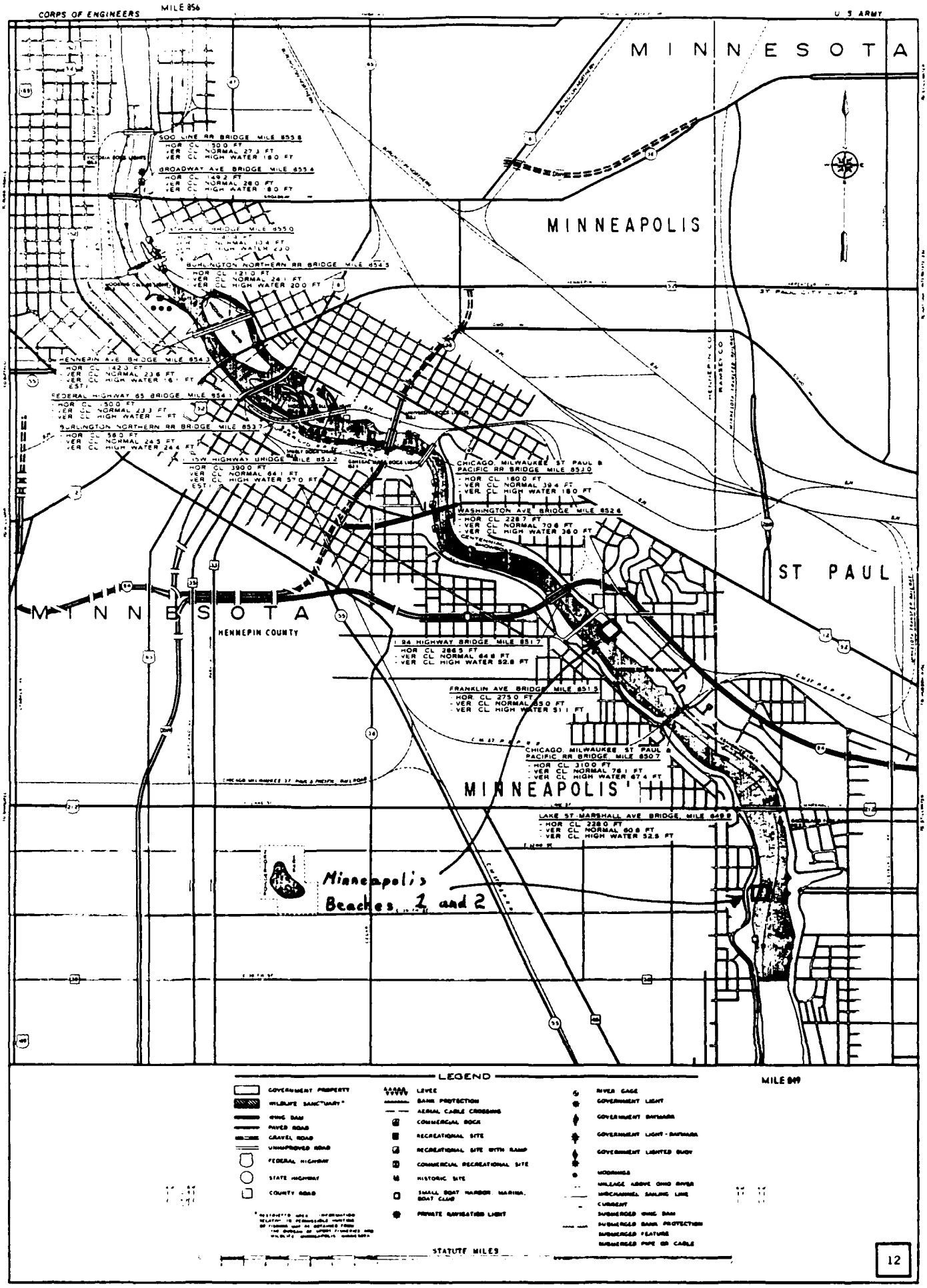
SUMMARY AND LOCATION OF REVEGETATION SITES

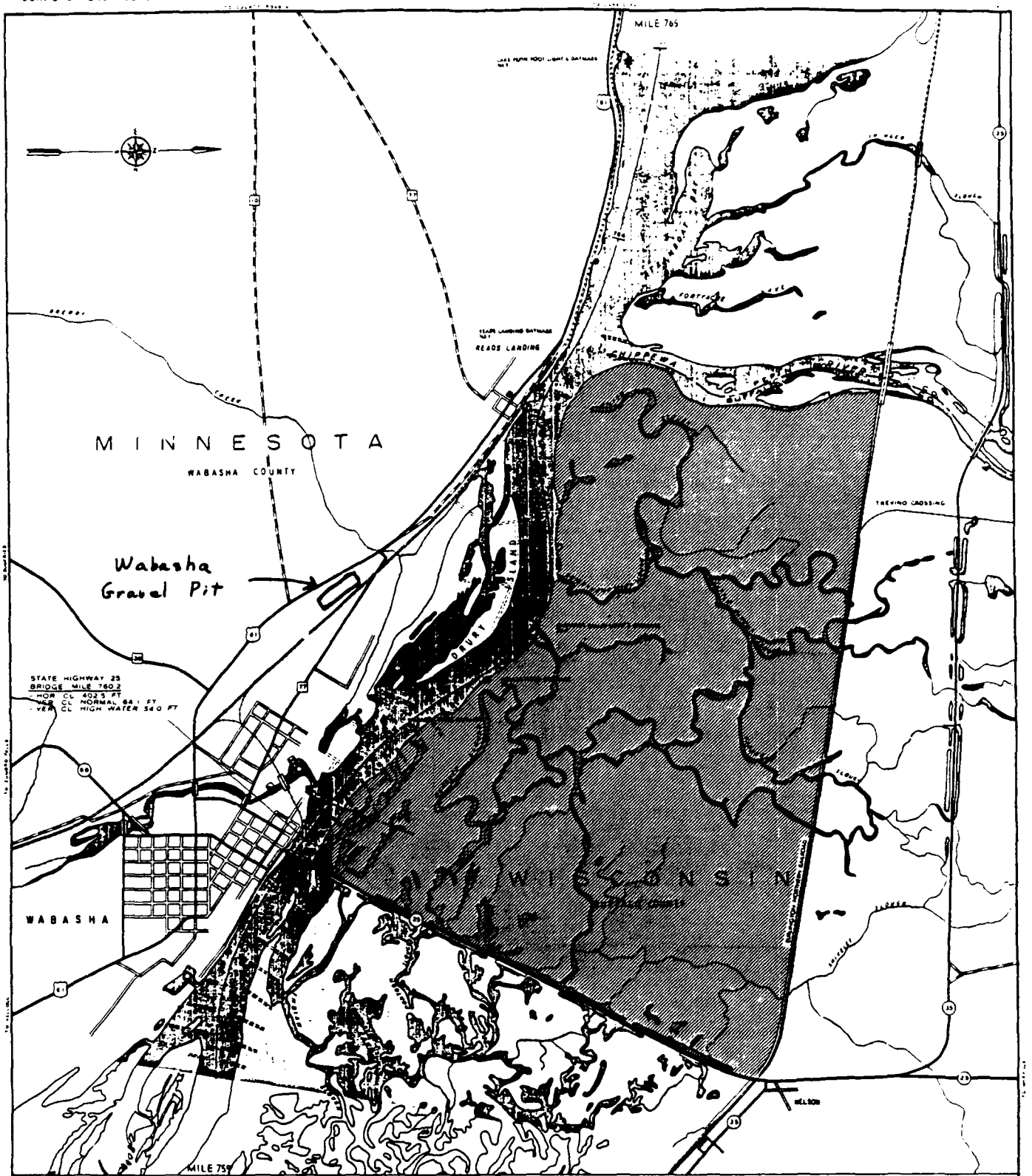
LIST OF REVEGETATION SITES

SITE NAME	RIVER MILE	AGENCY	DATE	METHODS
LOST ISLAND	745.0	COE	5/82	SEEDED AND HYDROMULCHED SIDE SLOPE OF BATHTUB. SMALL SEEDED AREA OF ANNUAL RYE. SPECIES SEEDED WERE RED CLOVER, YELLOW SWEETCLOVER, SWITCHGRASS, SAND DROPSEED, ANNUAL RYE.
	745.0	COE/FWS	5/15/85	SECOND SEEDING OF A SMALL PORTION OF AREA SEEDED IN 1982. SPECIES SEEDED WERE BLAZER PERENNIAL RYEGRASS, SWITCHGRASS, SIDE OATS GRAMA, LITTLE BLUESTEM, BIG BLUESTEM, CANADA WILD RYE, AND CROWN VETCH.
TEEPEEOTA POINT	757.3	COE	8-9/84	BACKWATER DREDGED MATERIAL (SILT AND CLAY) PLACED ON TOP OF SAND BY IRRIGATION SPRAYER. AREA NOT SEEDED.
CROSBY ISLAND	690.5	U OF WIS	5/28/74	PLANTED BEACHGRASS SPRIGS.
	690.5	COE/FWS	5/14/85	SEEDED SIDE SLOPE OF BATHTUB AND DRAGGED FENCE OVER AREA. NO MULCH. SPECIES SEEDED WERE BLAZER PERENNIAL RYEGRASS, SWITCHGRASS, SIDE OATS GRAMA, LITTLE BLUESTEM, BIG BLUESTEM, CANADA WILD RYE, AND CROWN VETCH.
	690.5	COE/FWS	4/30/86	TRANSPLANTED BEACHGRASS SPRIGS TO SIDE SLOPE OF DISPOSAL SITE.
JACKSON ISLAND	644.5	COE/FWS	5/30/84	FINE SEDIMENT DREDGED FROM LOCK AND PLACED ON SAND. AREA SEEDED. SPECIES SEEDED WERE SWITCHGRASS, BIG BLUESTEM, SIDE OATS GRAMA, AND INDIAN GRASS
MINNEAPOLIS PARK BEACHES 1 AND 2	851.5 849.5	COE	11/86	SEEDED AND HAY MULCH. SPECIES INCLUDE SAND DROPSEED, SWITCHGRASS, BLUE GRAMA, SIDE OATS GRAMA LITTLE BLUESTEM, CROWNVETCH, PERENNIAL RYEGRASS, KENTUCKY BLUEGRASS. MULCHED AT 2 TONS PER ACRE.
ISLAND 58 (UN-NAMED)	735.0	COE	6/85	FINE SEDIMENT DREDGED FROM LOCK AND PLACED ON SEDIMENT. AREA NOT SEEDED.

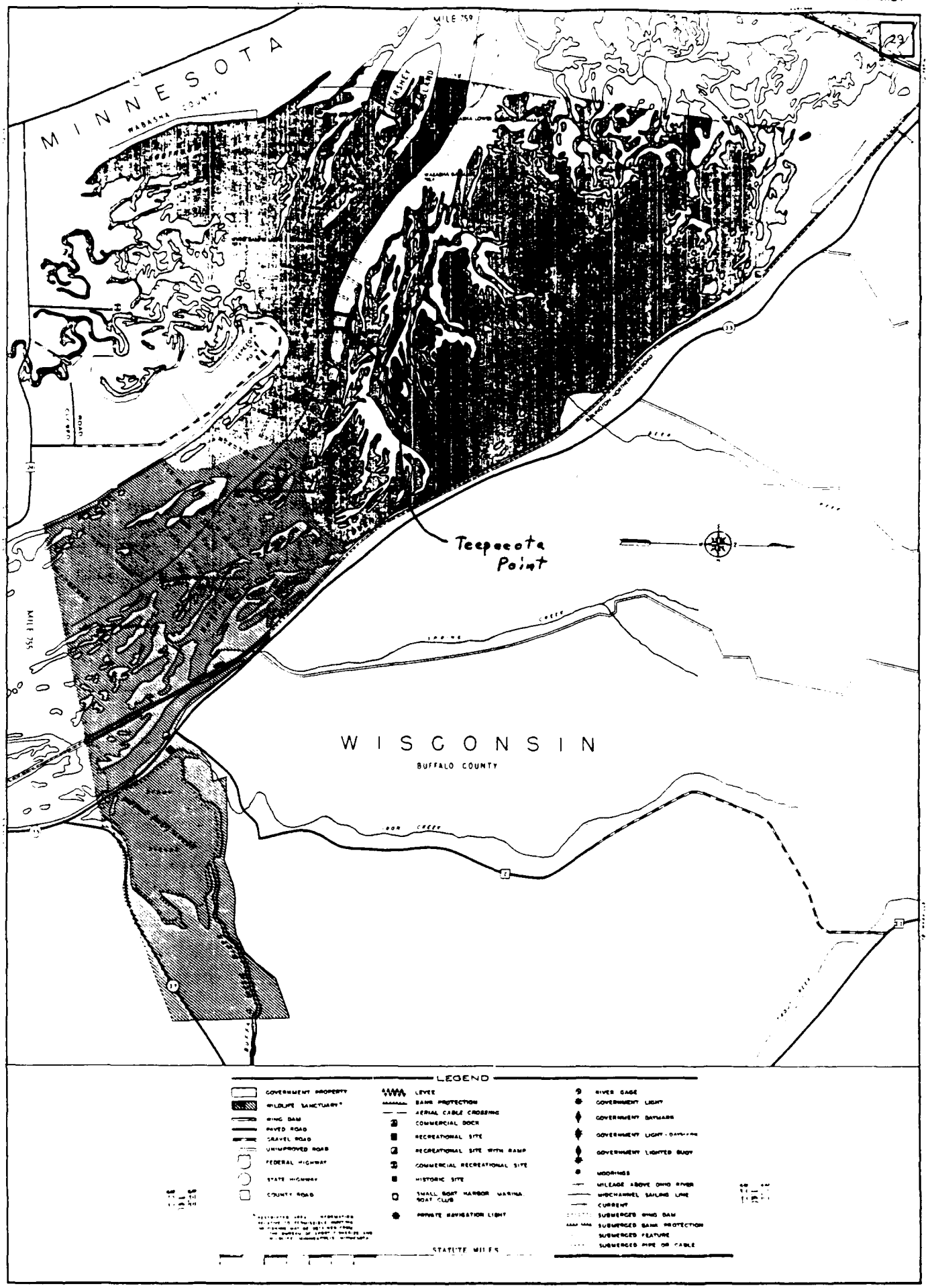
LIST OF REVEGETATION SITES -- CONTINUED

WABASHA GRAVEL PIT	760.0	COE	9/85	TEMPORARY GROUND COVER ESTABLISHED. SEED WAS BROADCAST AND SITE WAS RUN OVER WITH A SPRING-TOOTH HARROW. SPECIES INCLUDED SWITCHGRASS, YELLOW SWEET CLOVER, ALSIKE CLOVER, AND ANNUAL AND/OR PERENNIAL RYEGRASS. NO MULCH WAS APPLIED. REEDS LANDING SAND PLACED IN PIT IN 1984 AND 1985.
ALMA MARINA	754.0	COE/CITY	1984 to 85	SAND AND FINE MATERIAL PLACED BY COE IN 1984. IN 1985 CITY OF ALMA GRADED AND PLACED 8 INCHES OF CLAY ON TOP. DRILL SEEDED RYE, FESCUE, AND BLUEGRASS IN FALL 1985 AT 80 LBS./ACRE.
WEAVER BOTTOMS (ISLANDS AND CLOSURES)	745.0	COE/FWS	SWAN & MN12 JUNE 1988 MN11 & 13 & WI 10B & C JULY 1988	BACKWATER DREDGE MATERIAL PLACED ON SAND. SEEDED AND MULCHED. SWAN ISLAND SEEDED WITH INDIANGRASS, SWITCHGRASS, BLUESTEM, AND WILDRYE. MALLARD ISLAND NOT SEEDED. MN 11 SEEDED WITH CORDGRASS, SWITHGRASS, BLUESTEM, AND GRAMA. MN 12 SEEDED WITH DROPSEED AND BEACHGRASS SPRIGS PLANTED. MN 13 SEEDED WITH WHEATGRASS, NEEDLEGRASS, AND WILDRYE AND RICE CUTGRASS SPRIGS PLANTED. WI 10B & C SEEDED WITH BLUESTEM, INDIANGRASS, AND RYE -- (RAKED NOT MULCHED).
ISLAND 42 EMP	749.0	MNDNR	JUNE 1987	SEEDED, RAKED IN, BUT NOT MULCHED. ABOUT 100 LBS./AC. RYE, BLUEGRASS, BROME, TIMOTHY, SAND DROPSEED, AND BIRDSFOOT TREFOIL.


CORPS OF ENGINEERS
MILE 856
U S ARMY
MINNESOTA
MINNEAPOLIS
ST PAUL
HENNEPIN COUNTY
SOO LINE RR BRIDGE MILE 855.8
HOR CL 500 FT
VER CL NORMAL 27.3 FT
VER CL HIGH WATER 18.0 FT
BROADWAY AVE BRIDGE MILE 855.4
HOR CL 149.2 FT
VER CL NORMAL 28.0 FT
VER CL HIGH WATER 8.0 FT
BURLINGTON NORTHERN RR BRIDGE MILE 854.5
HOR CL 121.0 FT
VER CL NORMAL 26.1 FT
VER CL HIGH WATER 20.0 FT
HENNEPIN AVE BRIDGE MILE 854.3
HOR CL 422.0 FT
VER CL NORMAL 23.6 FT
VER CL HIGH WATER 16.1 FT
EST.
FEDERAL HIGHWAY 65 BRIDGE MILE 854.1
HOR CL 500 FT
VER CL NORMAL 23.3 FT
VER CL HIGH WATER — FT
BURLINGTON NORTHERN RR BRIDGE MILE 853.7
HOR CL 58.0 FT
VER CL NORMAL 24.5 FT
VER CL HIGH WATER 24.4 FT
I-35W HIGHWAY BRIDGE MILE 853.2
HOR CL 390.0 FT
VER CL NORMAL 66.1 FT
VER CL HIGH WATER 57.0 FT
EST.
CHICAGO MILWAUKEE ST PAUL & PACIFIC RR BRIDGE MILE 853.0
HOR CL 180.0 FT
VER CL NORMAL 39.4 FT
VER CL HIGH WATER 18.0 FT
WASHINGTON AVE BRIDGE MILE 852.6
HOR CL 228.7 FT
VER CL NORMAL 70.6 FT
VER CL HIGH WATER 36.0 FT
I-94 HIGHWAY BRIDGE MILE 851.7
HOR CL 286.5 FT
VER CL NORMAL 64.8 FT
VER CL HIGH WATER 52.8 FT
FRANKLIN AVE BRIDGE MILE 851.3
HOR CL 275.0 FT
VER CL NORMAL 69.0 FT
VER CL HIGH WATER 51.1 FT
CHICAGO MILWAUKEE ST PAUL & PACIFIC RR BRIDGE MILE 850.7
HOR CL 310.0 FT
VER CL NORMAL 78.1 FT
VER CL HIGH WATER 67.4 FT
LAKE ST MARSHALL AVE BRIDGE MILE 849.9
HOR CL 228.0 FT
VER CL NORMAL 60.8 FT
VER CL HIGH WATER 52.5 FT
Minneapolis Beaches 1 and 2
MILE 849
LEGEND
GOVERNMENT PROPERTY
WILDLIFE SANCTUARY*
DIKE DAM
PAVED ROAD
GRAVEL ROAD
UNIMPROVED ROAD
FEDERAL HIGHWAY
STATE HIGHWAY
COUNTY ROAD
LEVEE
BANK PROTECTION
AERIAL CABLE CROSSING
COMMERCIAL DOCK
RECREATIONAL SITE
RECREATIONAL SITE WITH RAMP
COMMERCIAL RECREATIONAL SITE
HISTORIC SITE
SMALL BOAT HARBOR MARINA, BOAT CLUB
PRIVATE NAVIGATION LIGHT
RIVER GAGE
GOVERNMENT LIGHT
GOVERNMENT BEACON
GOVERNMENT LIGHT - BEACON
GOVERNMENT LIGHTED BUOY
MOORINGS
MILEAGE ABOVE OHIO RIVER
MISCHANNEL SAILING LINE
CURRENT
SUBMERGED DIKE DAM
SUBMERGED BANK PROTECTION
SUBMERGED FEATURE
SUBMERGED PIPE OR CABLE
STATUTE MILES
12


MILE 765
READS LANDING
MINNESOTA
WABASHA COUNTY
Wabasha Gravel Pit
DRURY ISLAND
STATE HIGHWAY 25
BRIDGE MILE 760.2
HOR CL 502.5 FT
VER CL NORMAL 64.1 FT
VER CL HIGH WATER 54.0 FT
WISCONSIN
WABASHA
MILE 759
NELSON
TREVINO CROSSING
LEGEND
GOVERNMENT PROPERTY
WILDLIFE SANCTUARY*
WING DAM
PAVED ROAD
GRAVEL ROAD
UNIMPROVED ROAD
FEDERAL HIGHWAY
STATE HIGHWAY
COUNTY ROAD
LEVEE
BANK PROTECTION
AERIAL CABLE CROSSING
COMMERCIAL DOCK
RECREATIONAL SITE
RECREATIONAL SITE WITH RAMP
COMMERCIAL RECREATIONAL SITE
HISTORIC SITE
SMALL BOAT HARBOR, MARINA, BOAT CLUB
PRIVATE NAVIGATION LIGHT
RIVER GAGE
GOVERNMENT LIGHT
GOVERNMENT BEACON
GOVERNMENT LIGHT - BEACON
GOVERNMENT LIGHTED BUOY
MOORINGS
MILEAGE ABOVE OHIO RIVER
UNDERWATER SAILING LINE
CURRENT
SUBMERGED WING DAM
SUBMERGED BANK PROTECTION
SUBMERGED FEATURE
SUBMERGED PIPE OR CABLE
STATUTE MILES

28


MILE 759
MINNESOTA
WABASHA COUNTY
Teepeecota Point
MILE 755
WISCONSIN
BUFFALO COUNTY
LEGEND
GOVERNMENT PROPERTY
WILDLIFE SANCTUARY*
WING DAM
PAVED ROAD
GRAVEL ROAD
UNIMPROVED ROAD
FEDERAL HIGHWAY
STATE HIGHWAY
COUNTY ROAD
LEVEE
BANK PROTECTION
AERIAL CABLE CROSSING
COMMERCIAL DOCK
RECREATIONAL SITE
RECREATIONAL SITE WITH RAMP
COMMERCIAL RECREATIONAL SITE
HISTORIC SITE
SMALL BOAT HARBOR MARINA BOAT CLUB
PRIVATE NAVIGATION LIGHT
RIVER GAGE
GOVERNMENT LIGHT
GOVERNMENT DAYMARK
GOVERNMENT LIGHT - DAYMARK
GOVERNMENT LIGHTED BUOY
MOORINGS
MILEAGE ABOVE OHIO RIVER
NINE-FOOT CHANNEL SAILING LINE
CURRENT
SUBMERGED WING DAM
SUBMERGED BANK PROTECTION
SUBMERGED FEATURE
SUBMERGED PIPE OR CABLE
STATUTE MILES

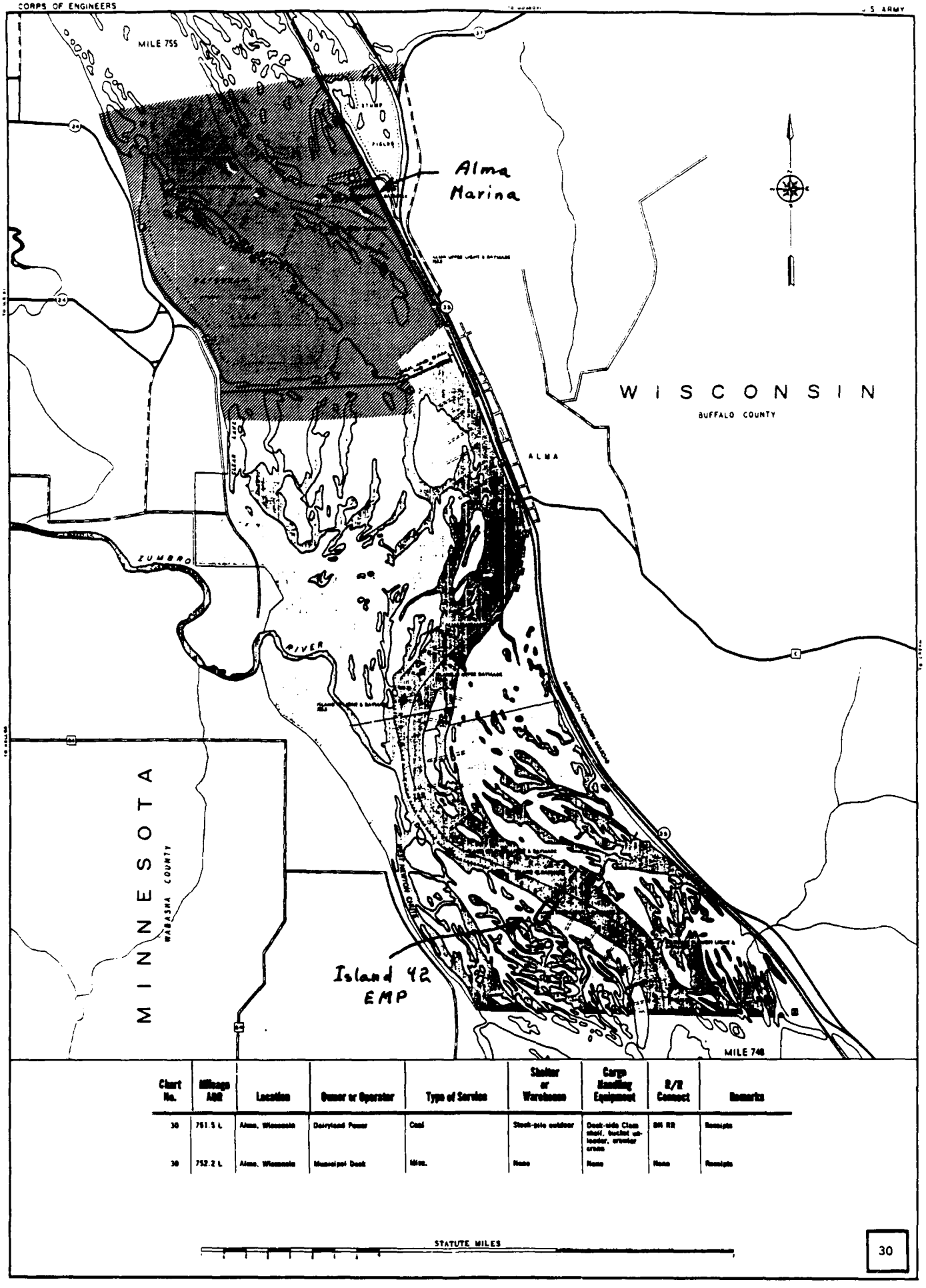
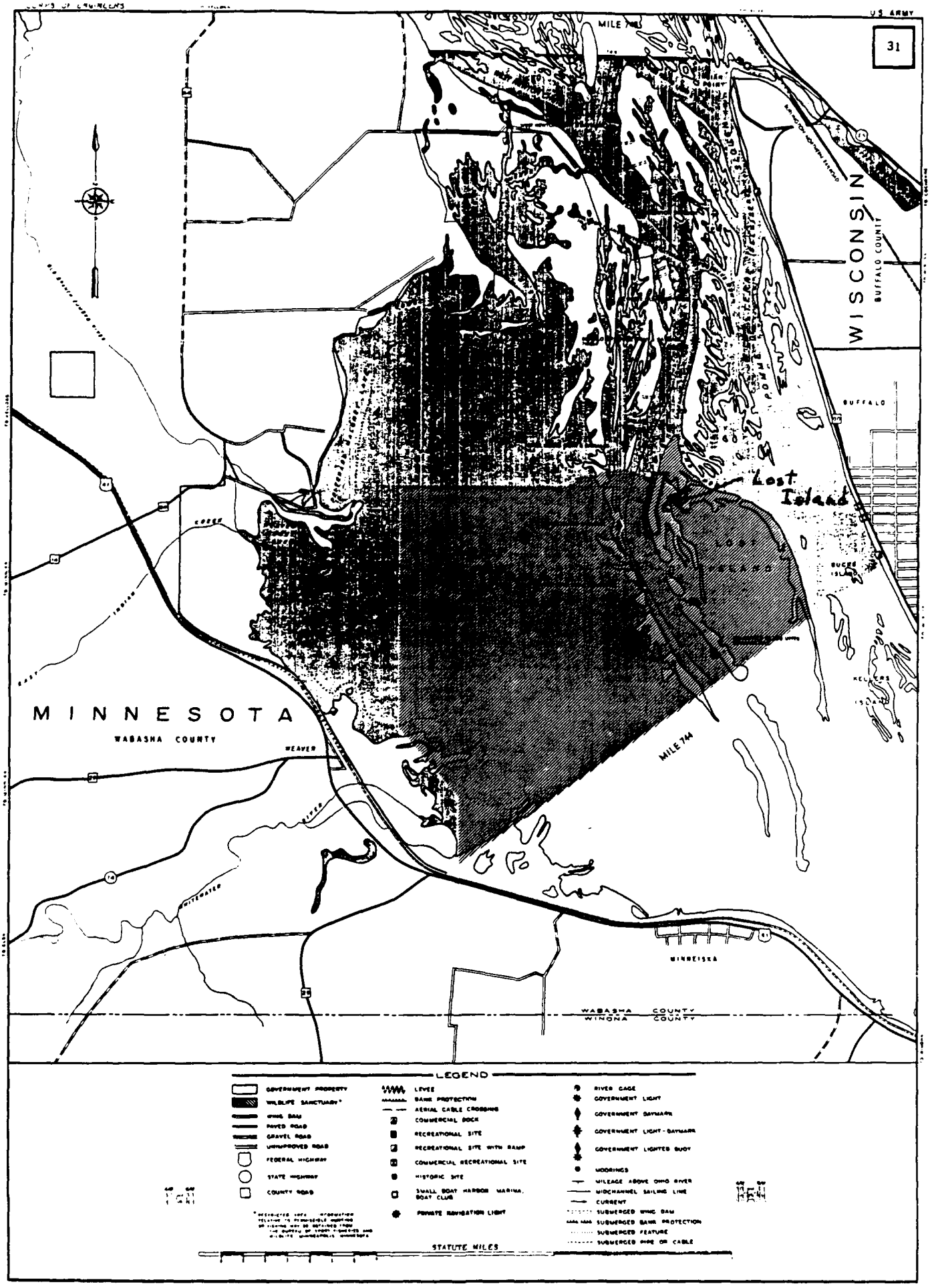
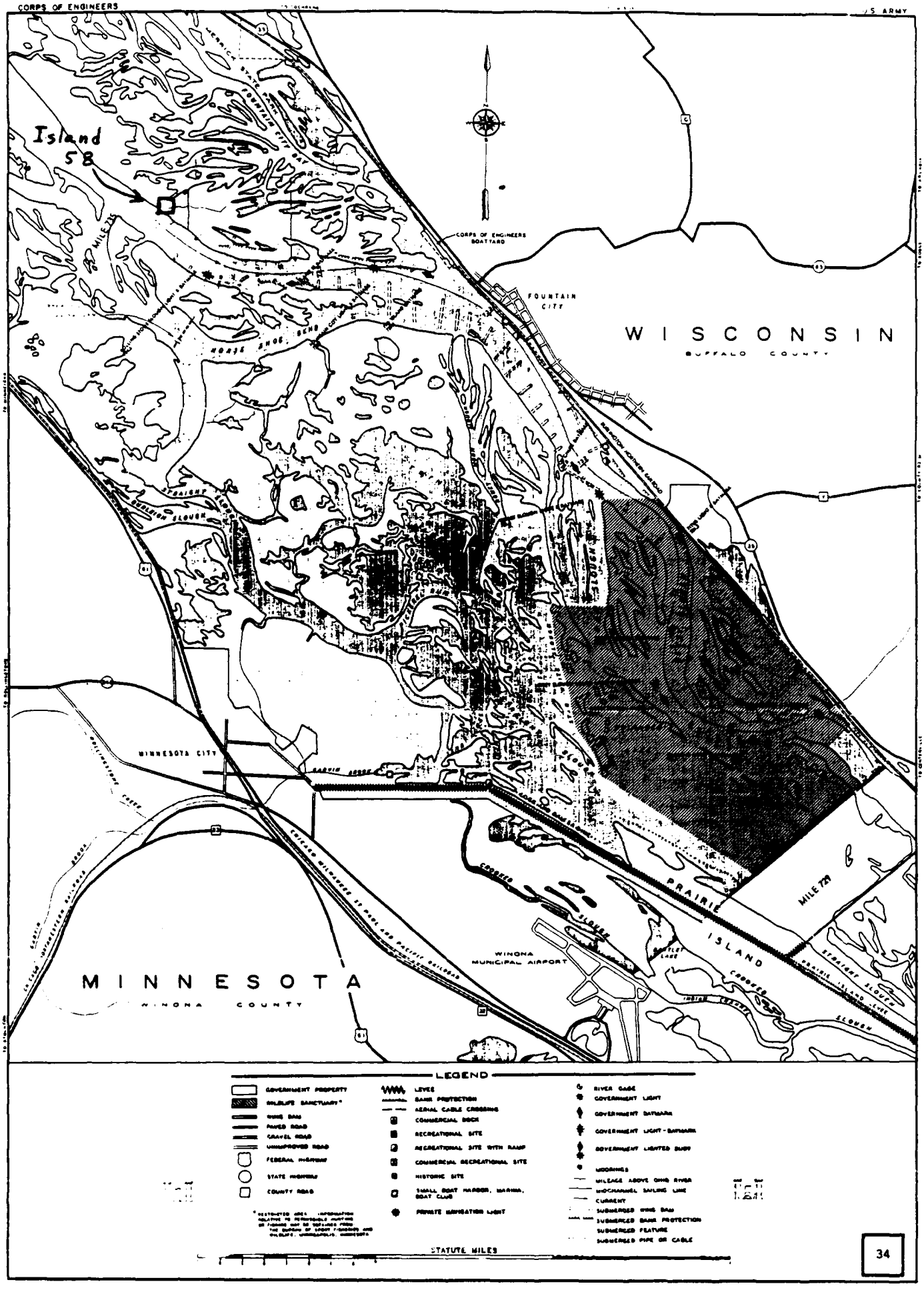
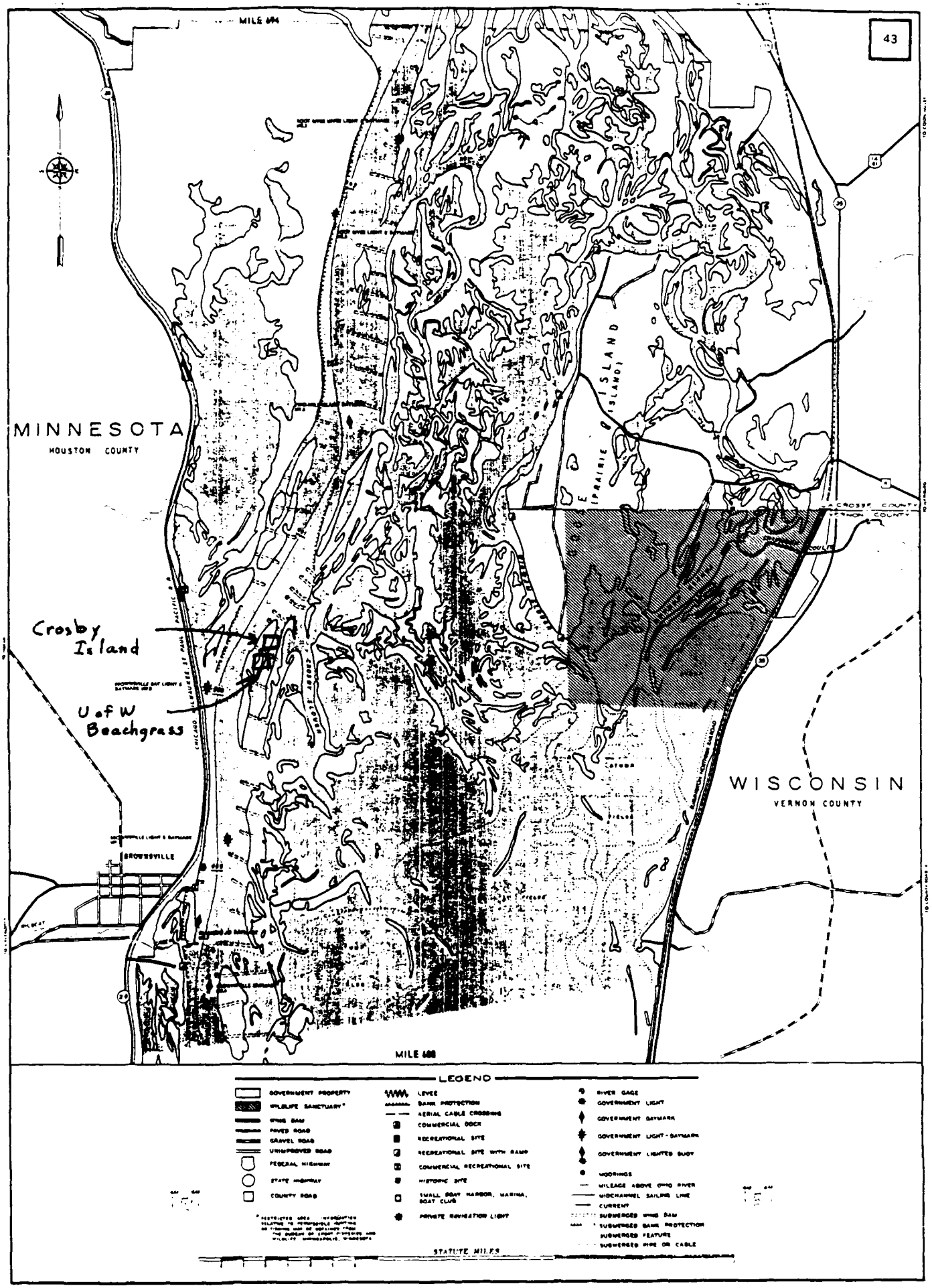
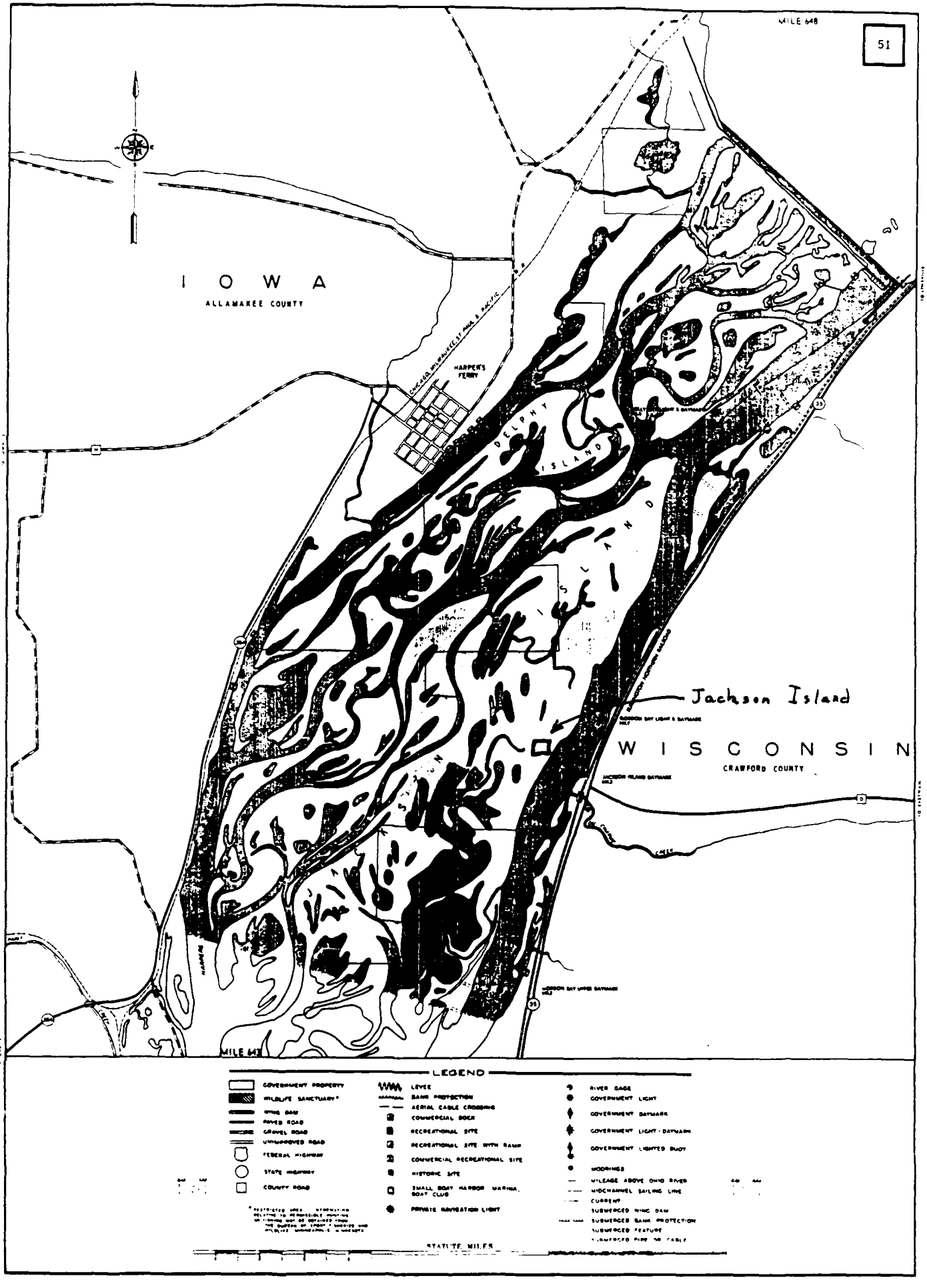


Chart No.	Mileage ABR	Location	Owner or Operator	Type of Service	Shelter or Warehouse	Cargo Handling Equipment	R/R Connect	Remarks
30	751.5 L	Alma, Wisconsin	Dairyland Power	Coal	Stock-pile outdoor	Dock-side Clam shovel, bucket unloader, crawler crane	BN RR	Receipts
30	752.2 L	Alma, Wisconsin	Municipal Dock	Misc.	None	None	None	Receipts


U.S. ARMY
31
MILE 746
WISCONSIN
BUFFALO COUNTY
BUFFALO
Lost Island
MINNESOTA
WABASHA COUNTY
WEAVER
MILE 744
MINNEISKA
WABASHA COUNTY
WINONA COUNTY
LEGEND
GOVERNMENT PROPERTY
WILDLIFE SANCTUARY*
WING DAM
PAVED ROAD
GRAVEL ROAD
UNIMPROVED ROAD
FEDERAL HIGHWAY
STATE HIGHWAY
COUNTY ROAD
LEVEE
BANK PROTECTION
AERIAL CABLE CROSSING
COMMERCIAL DOCK
RECREATIONAL SITE
RECREATIONAL SITE WITH RAMP
COMMERCIAL RECREATIONAL SITE
HISTORIC SITE
SMALL BOAT HARBOR MARINA, BOAT CLUB
PRIVATE NAVIGATION LIGHT
RIVER GAGE
GOVERNMENT LIGHT
GOVERNMENT DAYMARK
GOVERNMENT LIGHT-DAYMARK
GOVERNMENT LIGHTED BUOY
MOORINGS
MILEAGE ABOVE OHIO RIVER
MIDCHANNEL SAILING LINE
CURRENT
SUBMERGED WING DAM
SUBMERGED BANK PROTECTION
SUBMERGED FEATURE
SUBMERGED PIPE OR CABLE
STATUTE MILES


CORPS OF ENGINEERS
U.S. ARMY
Island 58
MILE 736
CORPS OF ENGINEERS BOATYARD
FOUNTAIN CITY
WISCONSIN
BUFFALO COUNTY
HORSE SHOE BEND
STRAIGHT SLOUGH
BUFFALO SLOUGH
MINNESOTA CITY
CHICAGO, MILWAUKEE, ST. PAUL AND PACIFIC RAILROAD
CORDUROY SLOUGH
PRAIRIE ISLAND
MILE 731
WINONA MUNICIPAL AIRPORT
MINNESOTA
WINONA COUNTY
LEGEND
GOVERNMENT PROPERTY
WILDLIFE SANCTUARY*
WING DAM
PAVED ROAD
GRAVEL ROAD
UNIMPROVED ROAD
FEDERAL HIGHWAY
STATE HIGHWAY
COUNTY ROAD
LEVEE
BANK PROTECTION
AERIAL CABLE CROSSING
COMMERCIAL DOCK
RECREATIONAL SITE
RECREATIONAL SITE WITH RAMP
COMMERCIAL RECREATIONAL SITE
HISTORIC SITE
SMALL BOAT HARBOR, MARINA, BOAT CLUB
PRIVATE NAVIGATION LIGHT
RIVER GAGE
GOVERNMENT LIGHT
GOVERNMENT BEACON
GOVERNMENT LIGHT - BEACON
GOVERNMENT LIGHTED BUOY
MOORINGS
MILEAGE ABOVE OHIO RIVER
MIDCHANNEL SAILING LINE
CURRENT
SUBMERGED WING DAM
SUBMERGED BANK PROTECTION
SUBMERGED FEATURE
SUBMERGED PIPE OR CABLE
* RESTRICTED AREA - INFORMATION RELATIVE TO PERMISSIBLE HUNTING OR FISHING MAY BE OBTAINED FROM THE BUREAU OF SPORT FISHERIES AND WILDLIFE, MINNEAPOLIS, MINNESOTA
STATUTE MILES
34


43
MILE 694
MINNESOTA
HOUSTON COUNTY
Crosby Island
U of W Beachgrass
WISCONSIN
VERNON COUNTY
BROWNSVILLE
MILE 688
LEGEND
GOVERNMENT PROPERTY
WILDLIFE SANCTUARY*
WING DAM
PAVED ROAD
GRAVEL ROAD
UNIMPROVED ROAD
FEDERAL HIGHWAY
STATE HIGHWAY
COUNTY ROAD
LEVEE
BANK PROTECTION
AERIAL CABLE CROSSING
COMMERCIAL DOCK
RECREATIONAL SITE
RECREATIONAL SITE WITH RAMP
COMMERCIAL RECREATIONAL SITE
HISTORIC SITE
SMALL BOAT HARBOR, MARINA, BOAT CLUB
PRIVATE NAVIGATION LIGHT
RIVER GAGE
GOVERNMENT LIGHT
GOVERNMENT DAYMARK
GOVERNMENT LIGHT - DAYMARK
GOVERNMENT LIGHTED BUOY
MOORINGS
MILEAGE ABOVE OHIO RIVER
MIDCHANNEL SAILING LINE
CURRENT
SUBMERGED WING DAM
SUBMERGED BANK PROTECTION
SUBMERGED FEATURE
SUBMERGED PIPE OR CABLE
STATUTE MILES


MILE 648
51
I O W A
ALLAMAKEE COUNTY
HARPER'S FERRY
DELPHY ISLAND
Jackson Island
W I S C O N S I N
CRAWFORD COUNTY
MILE 643
LEGEND
GOVERNMENT PROPERTY
WILDLIFE SANCTUARY*
WING DAM
PAVED ROAD
GRAVEL ROAD
UNIMPROVED ROAD
FEDERAL HIGHWAY
STATE HIGHWAY
COUNTY ROAD
LEVEE
BANK PROTECTION
AERIAL CABLE CROSSING
COMMERCIAL DOCK
RECREATIONAL SITE
RECREATIONAL SITE WITH RAMP
COMMERCIAL RECREATIONAL SITE
HISTORIC SITE
SMALL BOAT HARBOR MARINA, BOAT CLUB
PRIVATE NAVIGATION LIGHT
RIVER GAGE
GOVERNMENT LIGHT
GOVERNMENT DAYMARK
GOVERNMENT LIGHT - DAYMARK
GOVERNMENT LIGHTED BUOY
MOORINGS
MILEAGE ABOVE OHIO RIVER
MIDCHANNEL SAILING LINE
CURRENT
SUBMERGED WING DAM
SUBMERGED BANK PROTECTION
SUBMERGED FEATURE
STATUTE MILES

APPENDIX 3

REPORT ON THE PLACEMENT OF FINE MATERIAL AT TEEPEEOTA POINT

by Marc Krumholz

REVEGETATION OF DREDGED MATERIAL AT TEEPEEOTA POINT UPPER MISSISSIPPI RIVER MILE 757.6

Prepared by
Marc F. Krumholz

Department of the Army
St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, MN 55101

August 1984

Teepeeota Point
Revegetation Project
1984

Background

In the late 1970's as part of the channel maintenance program for the Upper Mississippi River, the Corps of Engineers constructed a number of confined on-land disposal facilities for the purpose of containing sand hydraulically dredged from the river's navigation channel. These facilities, often called bathtubs because of their configuration, have enabled the Corps to comply with the Clean Water Act and have allowed continued use of hydraulic dredges for a major portion of our channel maintenance in lieu of more expensive mechanical dredging methods in which the material is placed on barges and transported to more remote placement sites. Although these remote placement sites provide the potential for reuse of the dredged material for beneficial purposes such as construction fill, some historic dredging sites on the river require dredging more material than can be put to productive use over a reasonable period of time. Therefore, the Corps proposal is to expand the confined on-land disposal facility at Teepeeota Point, UMR mile 757.6.

This site has been used periodically since its initial construction in 1979 and has received approximately 178,000 cubic yards of dredged material, resulting in a stockpile of sand 30-40 feet above the adjoining land elevations in some areas. Because the dredged material is quite sterile medium grained sand, devoid of any vegetative cover, potential does exist for large scale erosion during a 100-year flood event. Therefore, concerned agencies requested the Corps to provide a stabilization experiment at this site prior to any expansion efforts.

Objective

With the information and techniques gained from this project applicable to other confined on-land disposal facilities (CDF) scattered throughout the District, the primary concern was to develop a low-cost method of establishing a vegetative cover which would significantly reduce the erosion potential through development of a root system and would further require very little maintenance. Aesthetic harmony with the surrounding environment was also expected as a secondary benefit.

An interagency meeting was held with appropriate field staff to discuss potential equipment alternatives and their feasibility, as well as potential sites for the dredging to take place. After reviewing the equipment and techniques possible it was agreed that a small hydraulic dredge (8-12 inches) placed into an adjacent backwater area would probably be best suited for the project. The material in the backwater was determined to be well-suited for encouraging vegetative growth and if properly planned could provide a secondary benefit to the shallow backwater area by providing habitat diversity. If necessary the disposal site would later be seeded to meet the objectives.

Scope of Work

The Teepeeota Point CDF is situated approximately 4.5 miles upstream of Lock and Dam No. 4 on the Upper Mississippi River. It is bordered by the main channel of the river on one side and a vast backwater complex on the other three sides. The site is 16 acres in size, 1700 feet in length with a width

varying from 450 feet on the upstream side to 250 feet on the downstream side. The original dike elevation is almost 30 feet above the normal water elevation and approximately an additional 20 feet higher on the upstream portion of the site where the dredged sand has been stockpiled in order to retain an operating capacity at the site and to maintain a retention pond on the downstream portion, complete with two 20-inch diameter pipes and associated weir structure to discharge the effluent. The outside slopes of the dike are approximately 5:1 horizontal to vertical and the inside slopes of the dike are 3:1. Prior to 1984 when an additional 64,000 cubic yards of material was placed on the site, a fairly level plateau existed on the upstream portion of the site which would have allowed for a small low head dike to be pushed up facilitating use of the dredge by effectively creating a smaller CDF within the much larger CDF site, thus allowing the material and effluent to pond. As it was the slope of the recently placed material had a 7-8:1 (H:V) slope inside the containment area, resulting in the finer material flowing off the site and into the original ponding area at the downstream portion of the site.

It was estimated that approximately 5,000 cubic yards of backwater material would be needed to adequately cover the site and provide a suitable vegetation substrate. The material was dredged from an adjacent backwater slough within 2,000 feet from the center of the disposal facility.

Equipment and Personnel

The dredge was a Mud Cat MC-915 eight-inch dredge with an auger type cutterhead. The unit drafted approximately 21 inches and was transported on a semi-tractor trailer bed. The unit was rented with operator to facilitate solution of any mechanical problems and to familiarize Corps personnel with the operating characteristics. Corps equipment on the site consisted of a D-7 bulldozer and a small John Deere 350 bulldozer. The smaller bulldozer, however, probably would have been sufficient to meet the needs. The discharge line included 500 feet of floating pipe and 2,000 feet of plastic, quick connect shorepipe in 20-foot lengths and 100 feet of spiller pipe. The spiller pipe is normal shorepipe with numerous 2-inch diameter holes perforated along the entire length to facilitate dispersion of material across a wider surface area. Two outboard motors and skiffs were used to transport fuel, equipment, and personnel to and from the site.

Personnel consisted of a dredge operator, a bulldozer operator and a general laborer to assist in laying the equipment out.

Method

Initially the pipeline was extended along the top of the downstream portion of the dike with the spiller pipe attached. When the dredge was started it quickly became evident that the spiller pipe would not adequately reduce the discharge velocities, and severe erosion began occurring. In lieu of attempting to further place material along the top of the dike, the discharge pipe was rerouted to the upstream portion of the site, directed towards the center of the recently deposited dredge material, and a small berm was pushed up approximately 150 reet in front of the discharge point. The intent of the berm was to temporarily pond the material discharged and to retain any erodable material presently on the site. The berm did not extend across the entire site. Again, erosion became a major problem when the effluent water which was being ponded began flowing around the berm washing away the sand.

It was then suggested by the dredge operator, that a traveling sprinkler system commonly used for agricultural irrigation may be feasible having used this technique in the past. During the effort to procure rental of a compatible sprinkler system, additional berming was done with the available manpower in an attempt to improve retention on the site. The additional berming which resulted in a low-head dike across the entire site resulted in similar erosion problems after the dredge was started. The operation was discontinued when the sprinkler equipment arrived.

The sprinkler equipment consisted of a revolving sprinkler head mounted on a three-wheeled chassis which could be dead-headed to an immobile object and automatically retrieved from up to 600 feet away. A booster pump was inserted into the discharge line in order to drive a six-inch pump containing a number of sharp blades for chopping any debris which might otherwise plug the orifice of the sprinkler head.

Because of the narrow flat surface area on top of the dike, the sprinkler was extended 600 feet away from the booster pump and dead-headed to one of the bulldozers for easy retrieval. The sprinkler head was pinned to encompass a 45° angle in order to spray only the outside slope of the dike. By throttling the booster pump a workman was able to impact only the inclined slope of the dike and could also adjust the retrieval rate so that the sprinkler could be advanced when erosion began occurring. Once the sprinkler was retrieved all the way to the dead-head, the sprinkler was again extended the entire 600 feet and a second pass was run. On each pass about 1/16 - 1/32 inches of fine material was sprayed onto the dike walls with greater accumulations in areas where the effluent could pond, such as the small furrows created by the bulldozer track and directly on top of the dike which was flat and approximately 10 feet wide. After three passes the sprinkler was moved to the upstream portion of the dike, which had been prepared by a bulldozer to increase the roughness of the slope and consequently increase retention of material on the slopes. This technique increased the thickness of material accumulating in the small furrows; however, because of swales along the dikes, erosion became more severe as the effluent drained into the lower-lying areas eventually over-topping the furrows. It is thought that an agricultural disc would be very advantageous, in that the disc could be run across the slopes after each pass of the sprinkler, thereby furrowing the slopes and exposing the porous sand. This would increase retention and also mix the fine material with the coarse sand for a better final substrate. This technique would also increase water percolation into the sand. As was the case, a portion of the fine material did run off the slopes once a relatively impermeable layer of silt was placed on the side slopes.

As a final test, the sprinkler was moved to the upper portion of the site which had been impacted by the recently placed material from the main channel. The sprinkler head was then allowed to rotate in a complete 360° arc and the sprinkler unit remained stationary. Because of the flatter slopes in this area, the technique proved to be quite effective and erosion never became a problem. The advantage of this technique was that the flatter slope allowed the excess water to either run off the slope with little head velocity or to percolate into the sand before being saturated again by another revolution of the sprinkler gun.

Cost

The total cost of this project which lasted from August 8 to September 13 was approximately $42,000. Of this, $26,000 was spent for rental of the mini-dredge, operator, and irrigation equipment. The irrigation equipment alone rented for $8,300 for the nine days it was on the site and $16,000 was spent for Corps-provided labor, equipment, fuel, and repairs.

Conclusion

Even though only a very thin layer of organic material was actually placed on the site, the Corps did, I believe, find a method by which a revegetation project could be done without extensive manpower or equipment needs. A site inspection one year after the project showed extensive coverage of vegetation on the areas impacted by the organic material. Several species of plants appeared to be thriving with winged pigweed being the predominant plant at this time. It is expected that plant succession will diversify the area in the coming years.

If the project were repeated I think the cost could be reduced as much as 60% based on the attached cost estimates. This would result in a cost per acre of $1,000-1,500 and would provide several inches of organic material on the project site.

Overall, valuable information was gained from the experiment and it would be my recommendation that the Corps incorporate this knowledge into their normal channel maintenance program to reduce the erosion potential at the many CDF's throughout the District.

Attached are several photos of the equipment used, the project site, and the operational problems.

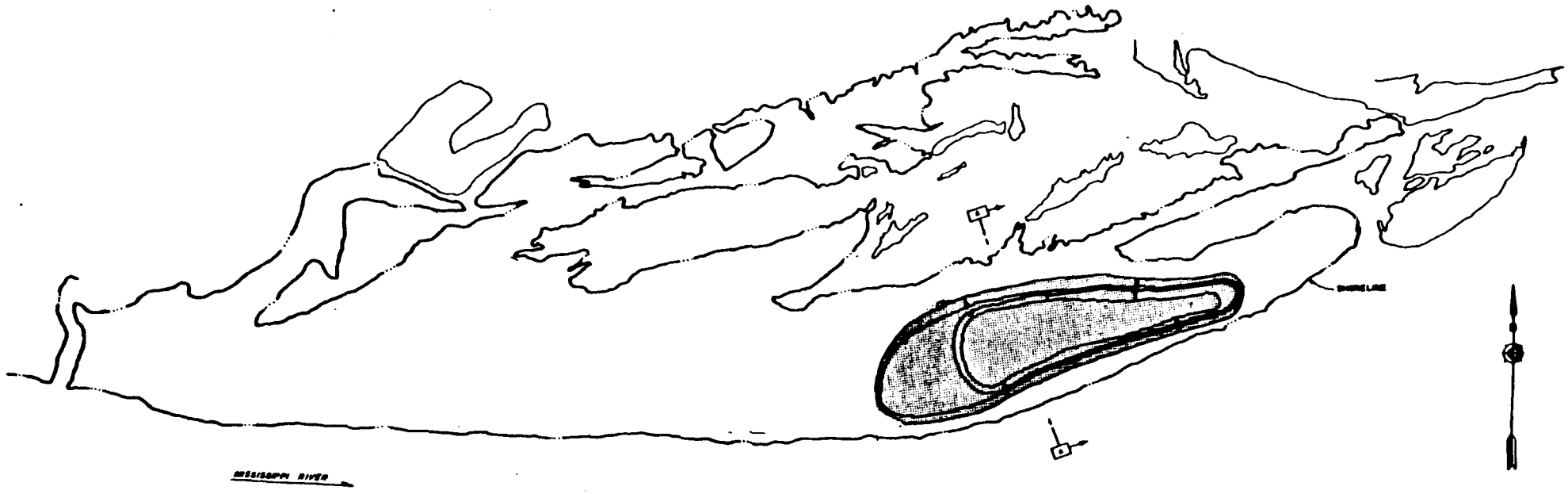
B

Cost Estimate
(For Similar Project in St. Paul District)

Item	Purpose	Cost
1. 2 work skiffs & 35 H.P. outboard motor	Transport dredge & other equipment to site	Loan receipt from Hydrographic Survey Unit at Fountain City Service Base.
2. 1 small deck cargo barge	Transport shorepipe & utility tractor too and from site	Loan from adjacent L/D for 1-2 days
3. 1 utility tractor or All-Terrain Vehicle	Disc site periodically to mix substrates, and to lay-out shorepipe.	Rent for nominal fee or through property loan from L/D or FCSB
4. Eight inch minidredge or similar piece of equipment and pipeline with operator.	Dredge backwater to provide suitable cover material.	$155/dredging hour. $75/hour standby hour. Assuming 80 hours at site with 55% effective time. Approximately $10,000

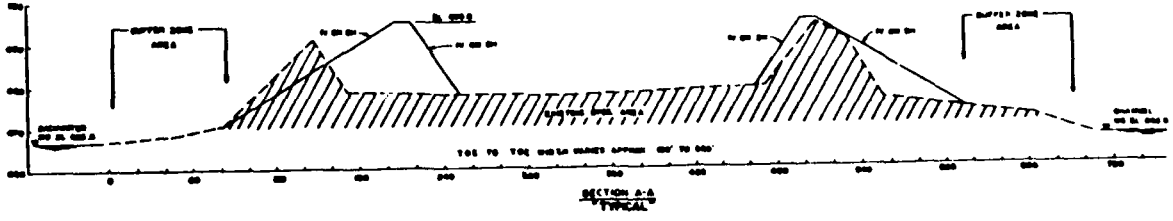
Note: Sand by-pass unit is presently on surplus at Corps' Duluth area office and could be transferred to St. Paul District for cost of transportation. This unit appears to be suited to projects based on information received. It would require rental of deck cargo barge and tender boat to transport to site.

5. 1 Supervisor/Laborer	Oversee project, assist with set-up and breakdown, transport daily fuel requirements, etc.	80 hrs. at $15/hr. including fringe benefits - $1200
6. 2 additional laborers for 4 days.	Assist with set-ups and breakdown at start and end of project to avoid excess standby time.	64 hrs. at $15/hr including fringe benefits - 768
7. Stationary sprinkler	Dispense dredged material in 360' radius.	2 week rental = $200
8. Chopper pump	Emulsify sticks and other debris so as to avoid plugging sprinkler orifice	Rental for two weeks - $1500 (Used piece of equipment could be purchased for $6500)
9. 100 H.P. tractor	Provide power to chopper pumps if unable to connect directly to dredge PTO shaft	2 week rental = $500
10. 1000 gallons fuel	Power equipment	$1000
Total Cost		$14,16[illegible] (Conservative Estimate using 12 acre site = $1180/acre)



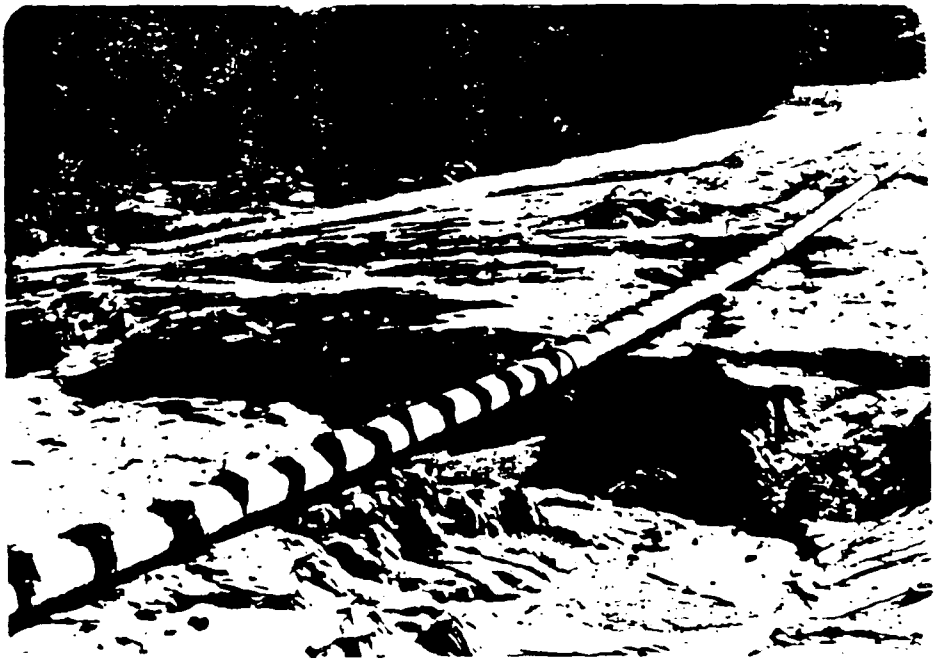
PLAN

SCALE IN FEET

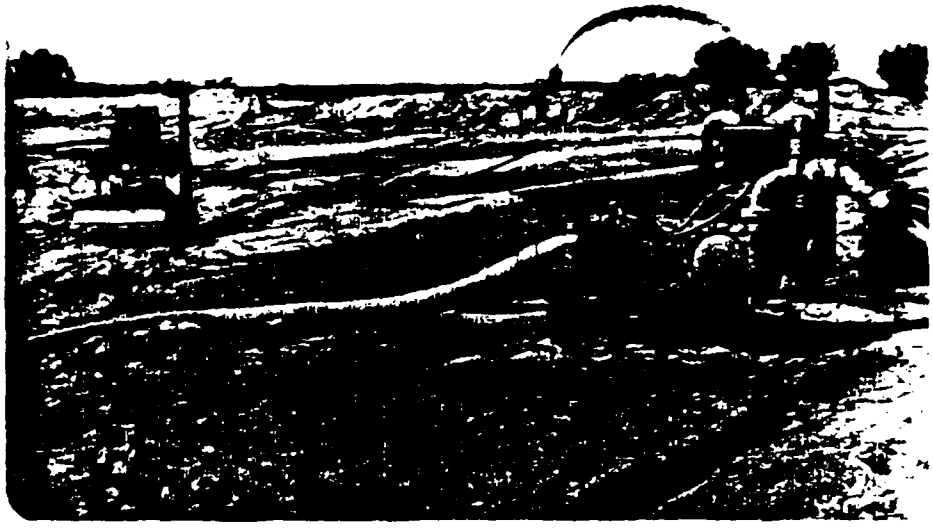


SECTION A-A
TYPICAL

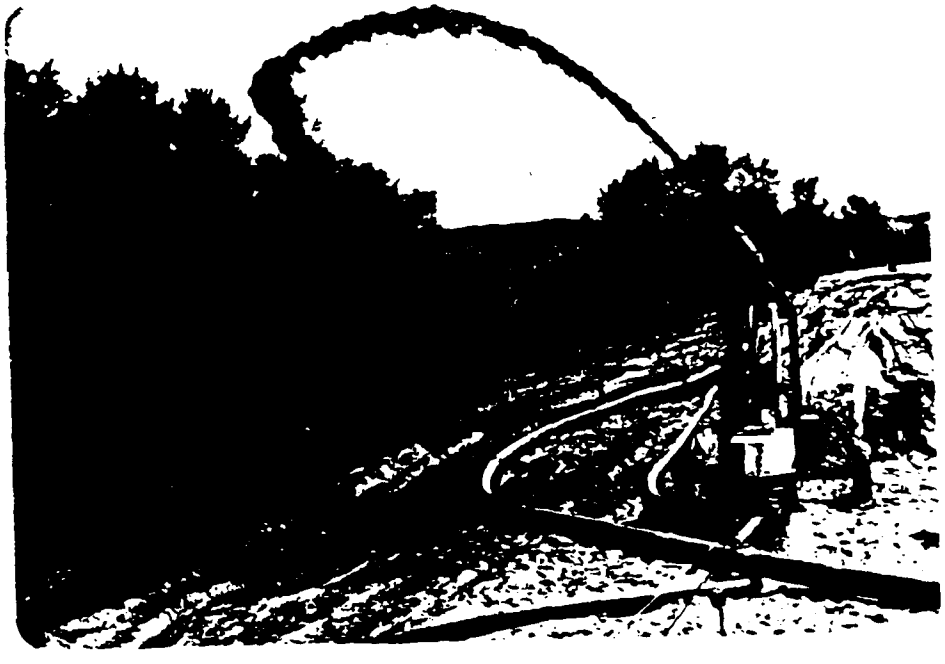
Containment area showing low-head berms across site.



Spiller pipe and erosion along top of dike.



Chopper pump with sprinkler in background.



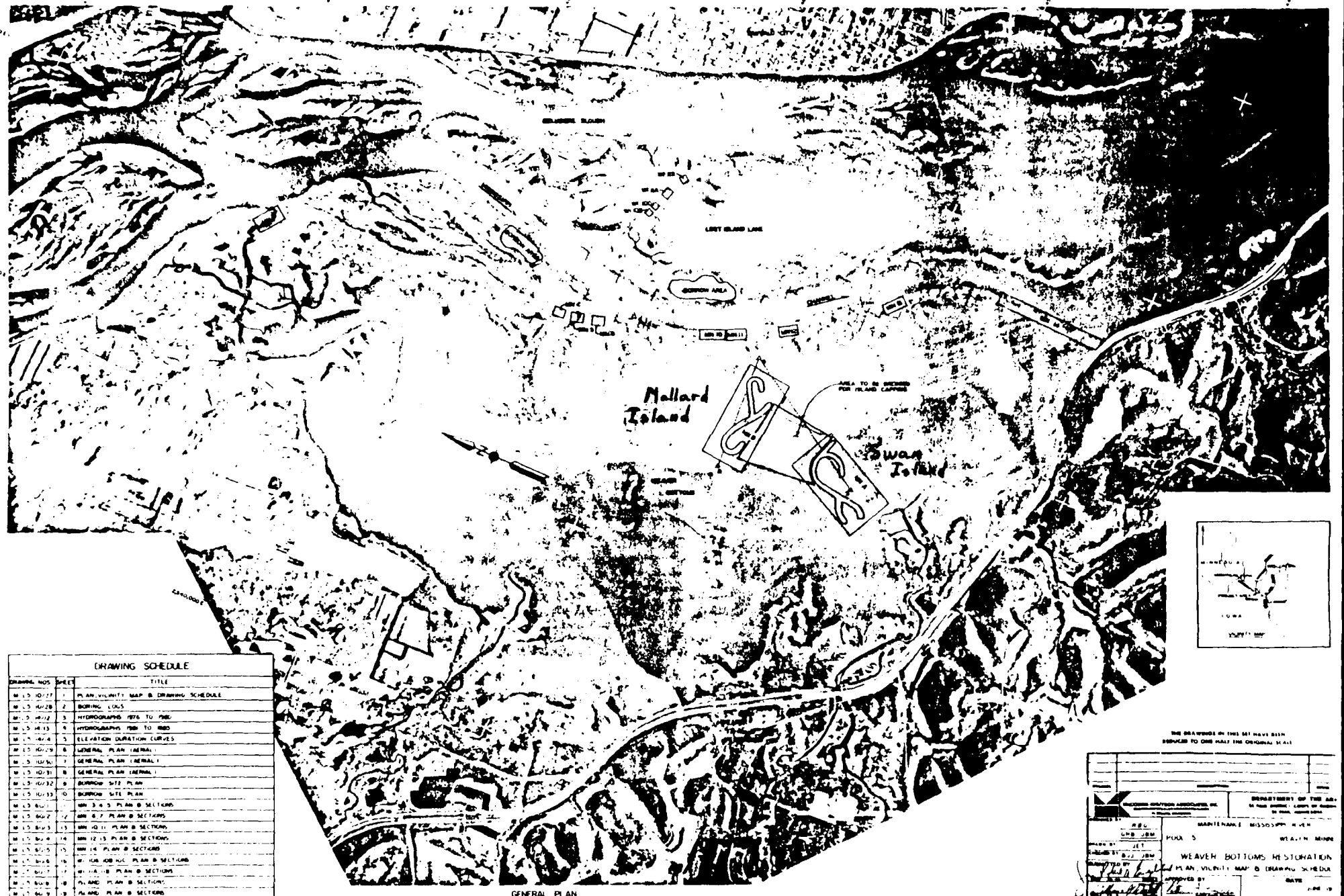
Sprinkler impacting outside slope of dike.

Side slope with and without furoughs created by bulldozer blade.

Partially dried organic sediment behind low-head berms.

APPENDIX 4

LOCATION OF REVEGETATION SITES AT WEAVER BOTTOMS



H-1

DRAWING SCHEDULE

DRAWING NOS.	SHEET	TITLE
M-5 10/27	1	PLAN, VICINITY MAP & DRAWING SCHEDULE
M-5 10/28	2	BORING LOGS
M-5 10/29	3	HYDROGRAPHS 1976 TO 1980
M-5 10/30	4	HYDROGRAPHS 1981 TO 1985
M-5 10/31	5	ELEVATION DURATION CURVES
M-5 10/32	6	GENERAL PLAN (AERIAL)
M-5 10/33	7	GENERAL PLAN (AERIAL)
M-5 10/34	8	GENERAL PLAN (AERIAL)
M-5 10/35	9	BORROW SITE PLAN
M-5 10/36	10	BORROW SITE PLAN
M-5 10/37	11	MH 3 & 5 PLAN & SECTIONS
M-5 10/38	12	MH 6,7 PLAN & SECTIONS
M-5 10/39	13	MH 10,11 PLAN & SECTIONS
M-5 10/40	14	MH 12,13 PLAN & SECTIONS
M-5 10/41	15	MH 14 PLAN & SECTIONS
M-5 10/42	16	MH 108,109,110 PLAN & SECTIONS
M-5 10/43	17	MH 118 PLAN & SECTIONS
M-5 10/44	18	ISLAND PLAN & SECTIONS
M-5 10/45	19	ISLAND PLAN & SECTIONS

THE DRAWINGS IN THIS SET HAVE BEEN REDUCED TO ONE HALF THE ORIGINAL SCALE

MAINTENANCE MISSISSIPPI RIVER

POOL 5 WABASHA MINN

WEAVER BOTTOMS RESTORATION

PLAN, VICINITY MAP & DRAWING SCHEDULE

APPROVED

DATE JUNE 19

AS SHOWN

M-5 10/27

APPENDIX 5

PHOTOGRAPHS OF REVEGETATION SITES

Figure 1. Removing material from Lost Island in 1986 to create islands in Weaver Bottoms. Seeded area on right side slope of island.

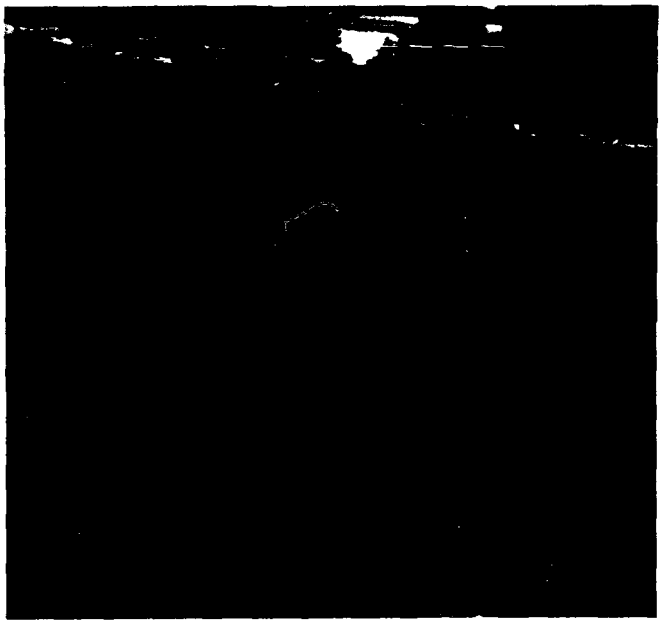


Figure 2. Lost Island seeded area in 1983. Note the large size of the winged pigweed due to fertilization in 1982.

Figure 3. South area of Lost Island in August of 1984. Trees are [illegible] percent.

Figure 4. Lost Island control area in 1988. Short grasses and woody species predominate.

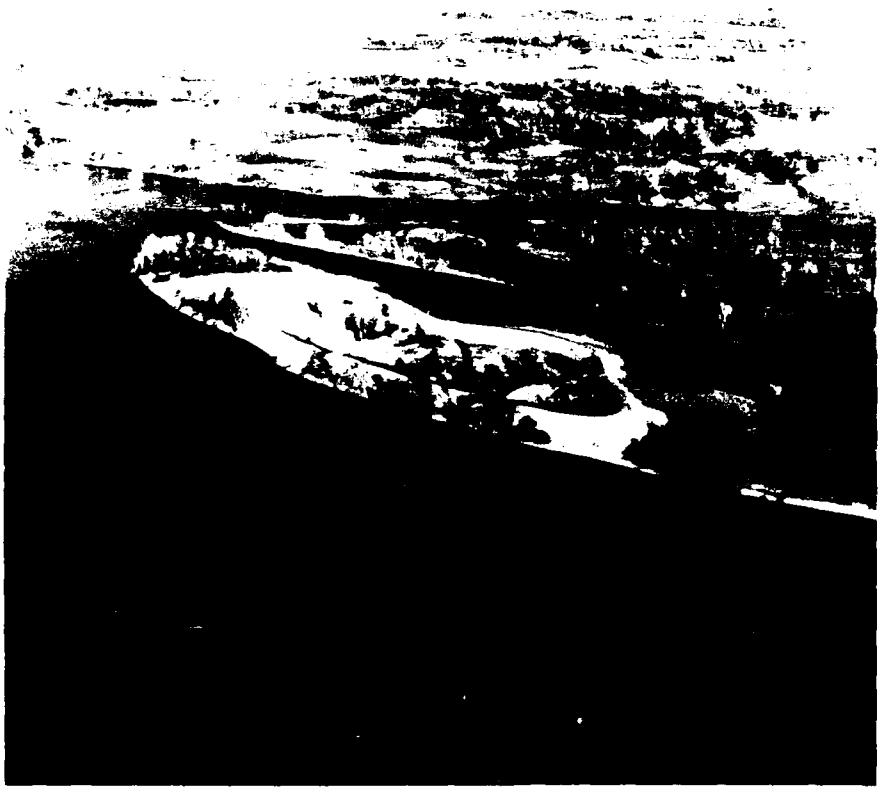


Figure 6. Aerial view of Crosby Island in 1986. Beachgrass plantings are on the right side of the island and the seeded area is on the back side of the island.

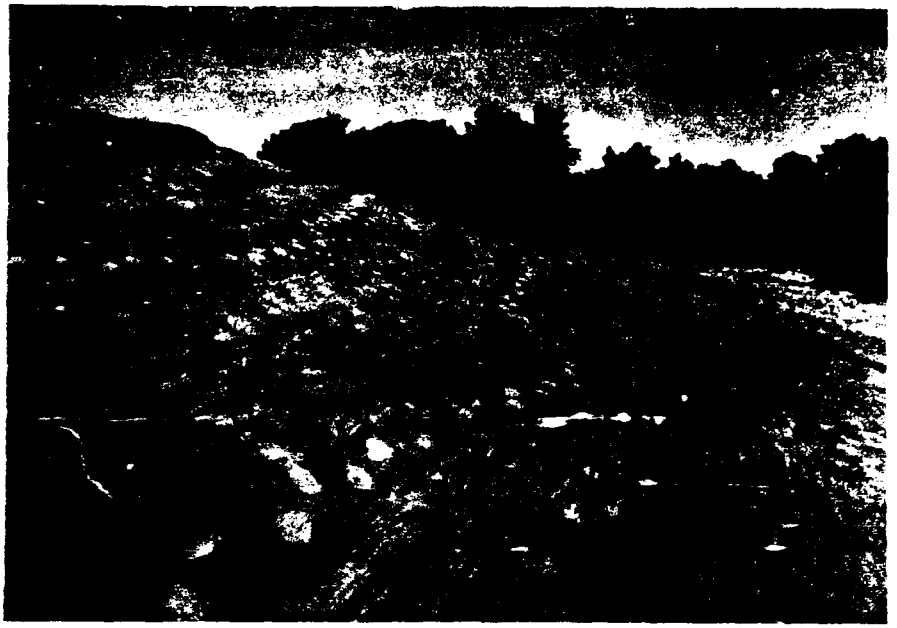


Figure [illegible] Crosby Island in May of 1985 after dragging [illegible] [illegible] [illegible] area.

Figure 8. In August of 1986 Canada wild rye was growing on the [illegible] area at Crosby Island.

Figure 9. Beachgrass plantings at Dewey Island in August [illegible]. Portion of area burned in lower left corner recovered the next [illegible].

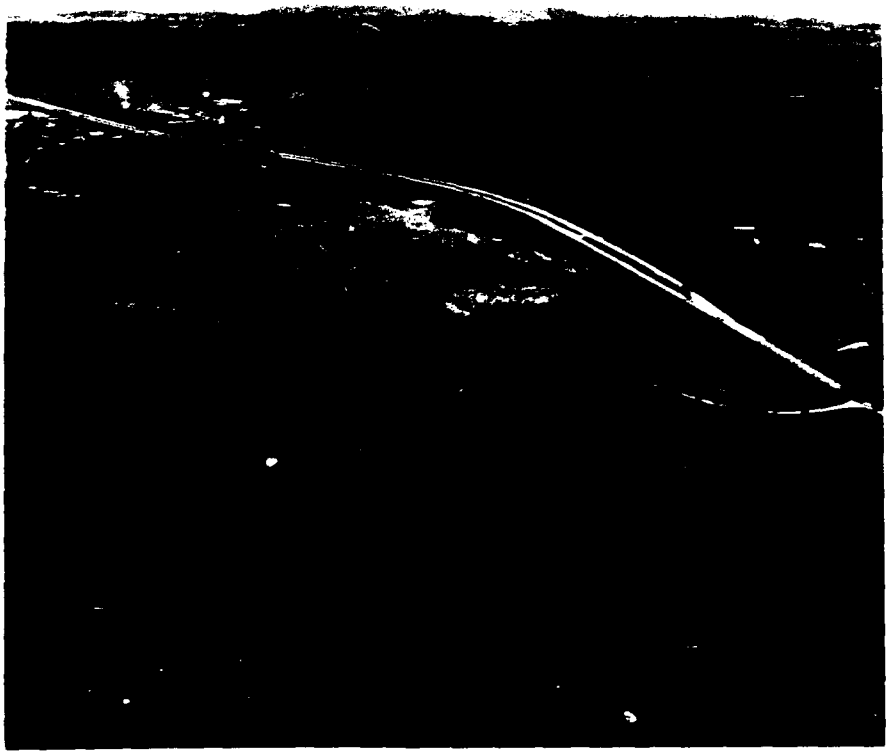


Figure 10. Aerial view of the Wabasha gravel pit in the summer of [illegible].

Figure 11. In August of 1988 the Wabasha gravel pit had about 1 percent cover.

Figure 12. Beneficial use of dredged material at the Alma Marina in 1986.

Figure 13. The city of Alma placed 8 inches of fine material over the sand and drill seeded rye, fescue, and bluegrass.

Figure 14. Aerial view of Teepeeota Point in 1986. Fine material was dredged from the open water area in back of the island.

Figure 15. Using an irrigation sprayer to place fine material on Teepeeota Point in August of 1984.

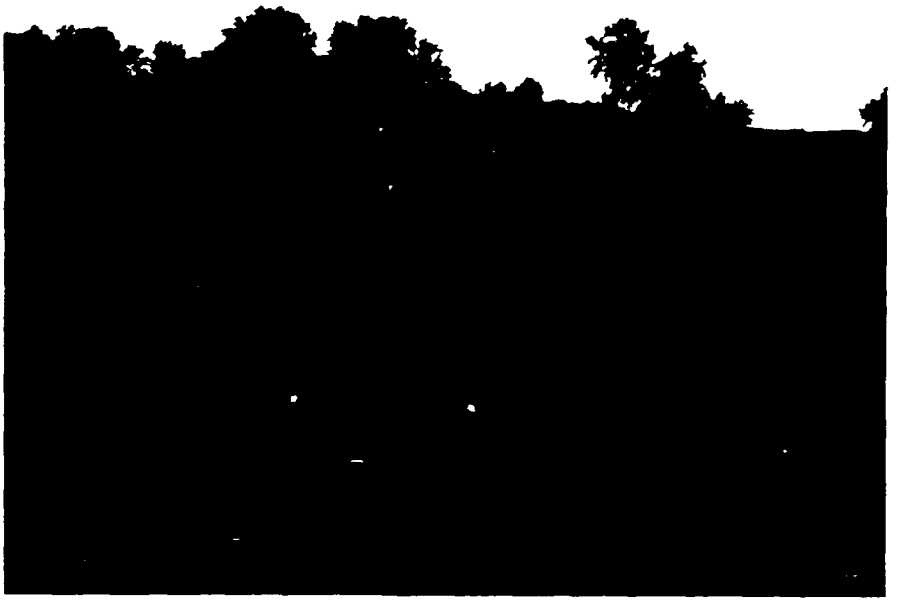


Figure 16. About 1 foot of fine material overflowed to the bottom of the area at Teepeeota Point resulting in a good growth of vegetation.

Figure 17. Winged pigweed in the bottom of the disposal area at Teepeeota Point area attained large size.

Figure 18. The sprayed area at Teepeeota Point had a cover of 13 percent in August of 1988.

Figure 19. Island 58 in August of 1985 soon after spreading the material. Cottonwood sprouts were already starting to appear.

Figure 20. In 1988 the cottonwood at Island 58 was over 10 feet tall. Grass species are not common.

Figure 21. Fine material at Jackson Island was mostly vegetated by weeds and grasses in 1984.

Figure 22. In 1985 weeds at Jackson Island decreased and grasses increased. Tree species have not established.

Figure 23. Island #2 in August of 1988. A very good grass cover has become established. The area was broadcast seeded at a rate of about 100 lbs. per acre.

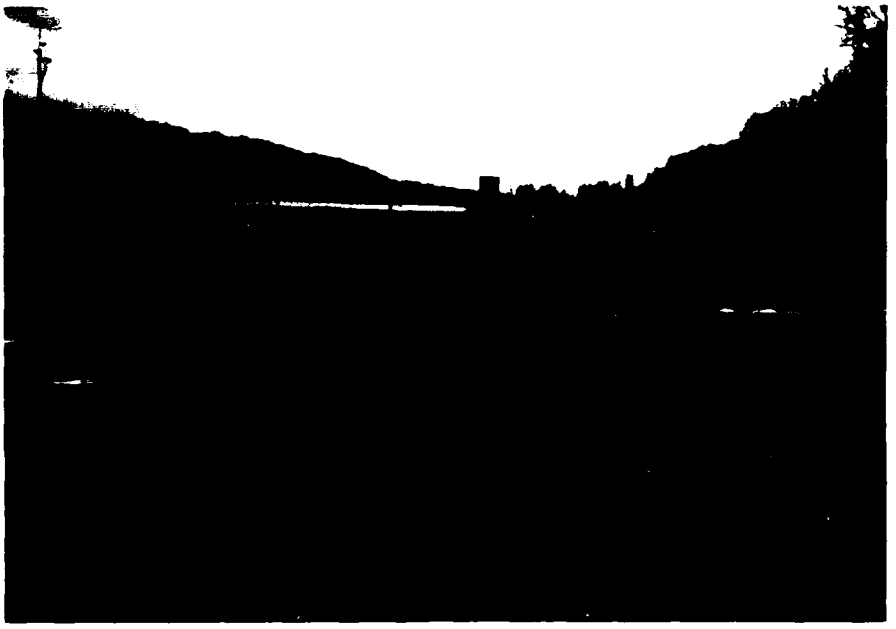


Figure 24. Minneapolis Park Beaches about 1 month after seeding. Heavy use has prevented good establishment.

Figure 25. Aerial view of Weaver Bottoms in 1987 showing Swan and Mallard Islands, the side channel closures, and Lost Island.

Figure 26. MN 10 in August of 1988. Winged pigweed predominates the control area.

Figure 27. Switchgrass was drill seeded on MN 11 in 1988.

Figure 28. Fine material was not placed on MN 12. Sand dropseed was drill seeded in 1988.

Figure 29. Fine material was placed on MN 13 and drill seeded in 1...

Figure 30. Fine material was spread on Mallard Island in July of 1988. The island was not seeded and is used as a control site.

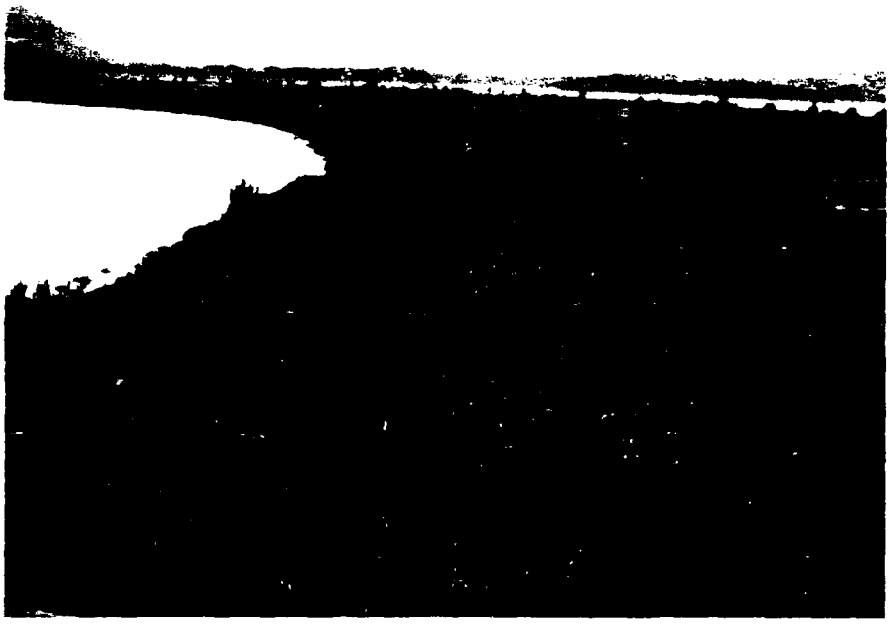


Figure 11. Swan Island was drill seeded. In August of [illegible] spring had germinated along with wild oats that was present in the mulch.

APPENDIX 6

LIST OF COMMON AND SCIENTIFIC NAMES

OF PLANT SPECIES MENTIONED IN REPORT

SCIENTIFIC AND COMMON NAMES MENTIONED IN THIS REPORT

Scientific Name	Common Name
Abutilon theophrasti	velvet leaf
Acer negundo	box elder
Acer rubrum	red maple
Acer saccharium	silver maple
Agropyron dasystachyum	thickspike wheatgrass
Agropyron repens	quackgrass
Andropogon gerardi	big bluestem
Andropogon scoparius	little bluestem
Amaranthus retroflexus	redroot (rough) pigweed
Ambrosia sp.	ragweed
Amophila brevilegulata	American beachgrass
Asclepias syriaca	milkweed
Aster sp.	aster
Berteroa incana	hoary alyssum
Bouteloua curtipendula	side oats grama
Bouteloua gracilis	blue grama
Bromus sp.	brome
Calamovilfa longifolia	sand reedgrass
Carex sp.	sedge
Cenchrus pauciflorus	sandbur
Chenopodium album	lambsquarters
Cirsium sp.	thistle
Convolulus sp.	bindweed
Convolulus sepium	bindweed
Coronilla varia	crown vetch
Cycloloma atriplicifolium	winged pigweed
Cyperus schweinitzii	umbrella sedge
Danthonia intermedia	wild oats
Digitaria sanguinalis	crabgrass
Echinochloa crusgalli	barnyard grass
Elymus canadensis	Canada wild rye
Erigeron sp.	horseweed
Erigeron canadensis	marestail
Erigeron strigosus	daisy fleabane
Euphorbia sp.	spurge
Euphorbia supina	milk purslane
Festuca sp.	fescue
Helianthus laetiflorus	showy sunflower
Hordeum jubatum	barley
Hordeum pusillum	little barley
Leersia oryzoides	rice cutgrass
Lepidium sp.	mustard
Liatris aspera	rough blazing star
Lolium sp.	annual rye
Lolium perenne	perennial rye
Lotus corniculatus	birdsfoot trefoil
Matricaria matricarioides	pineapple weed
Medicago sativa	alfalfa
Melilotus alba	white sweet clover

Melilotus officinalis	red clover
Mollugo verticillata	carpetweed
Muhlenbergia racemosa	timothy
Oenothera biennis	primrose
Panicum virgatum	switchgrass
Parthenocissus inserta	Virginia creeper
Phalaris arundinacea	reed canary grass
Pilea pumila	clearweed
Poa sp.	bluegrass
Poa pratensis	Park Kentucky bluegrass
Polanisia graveolens	clammyweed
Polygonum sp.	smartweed
Populus sp.	cottonwood
Potentilla sp.	cinquefoil
Quercus sp.	oak
Rhus sp.	sumac
Rhus radicans	poison ivy
Rorippa islandica	yellow cress
Rudbeckia hirta	black-eyed Susan
Rumex crispus	curly dock
Salix sp.	willow
Salsola kali	Russian thistle
Saponaria officinalis	bouncing bet
Secale cereale	rye
Setaria sp.	foxtail
Sisymbrium altissimum	tumbling mustard
Solanum sp.	nightshade
Sorghastrum nutans	Indiangrass
Spartina pectinata	prairie cordgrass
Sporobolus cryptandrus	sand dropseed
Sporobolus heterolepis	prairie dropseed
Stipa viridula	green needlegrass
Thalapsis purpura	purple sandgrass
Thlaspi arvense	pennycress
Tradescantia sp.	spiderwort
Trifolium hybridum	alsike clover
Trifolium pratense	red clover
Ulmus sp.	elm
Vitus riparia	grape